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Edited by

CARLETON REA and J. RAMSBOTTOM

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WINDSOR FORAY.

September 28th to October 3rd, 1923.

By E. M. Wakefield, M.A., F.L.S.

The twenty-seventh Autumn Foray and Annual General Meeting of the Society was held at Windsor from Friday, September 28th, to Wednesday, October 3rd. The headquarters were at the White Hart Hotel, where a large room was secured for the meetings and exhibition of specimens. Here a large number of species collected in Windsor Forest by some of the earlier arrivals were exhibited. Mr Metcalfe Day brought *Tricholoma psammopum* from Minchinhampton.

On the Friday evening the Council nominated officers and new members of Council for election at the General Meeting on the morrow, and discussed the programme for 1924. Reading, under the guidance of Mr Buddin, was suggested as the locality for the Phytopathological excursion in the summer—the date being left to be considered in connection with the Imperial Botanical Conference.

On Saturday a start was made at 10.0 a.m., and Virginia Water was searched. Specially noteworthy was the great abundance of *Amanita mappa*, this and *Russula ochroleuca* being encountered in quantity. *Amanita phalloides*, on the other hand, was very scarce, both here and elsewhere during the foray. One or two fine specimens of *Sparassis crispa* were found at the foot of some pines near the lake. Some members who had been at the Oxshott day foray in October 1922, and had found there a beautiful pink Discomycete, were extremely interested to meet with the species again here—growing under similar conditions beneath tufts of *Epilobium angustifolium*. The species was collected again on the fourth day of the foray. This was subsequently found to be an undescribed species allied to *Pustularia bolaris* (Bres.) Boud. *Aleuria Emileia* was another find on this day, as well as several rare Agarics.

In the evening the General Meeting was held. Mr Ramsbottom was elected President for 1924, Miss Lister Vice-President, and Messrs W. J. Dowson and C. J. Sharpe to the Council. The other officers were re-elected.

Meetings were arranged as in 1923, that is, three London meetings, a Spring and an Autumn Foray, a Phytopathological excursion, two Students' day forays, and day forays with the Essex Field Club and the British Ecological Society.

As alternatives to Buxton, already suggested for the Spring Foray, Tintern and Salisbury were proposed, but a small majority favoured Buxton.

For the Autumn Foray Sherwood Forest and North Wales were discussed. North Wales, with headquarters at Bettws-y-Coed, was decided upon provided arrangements could be made.

Mr Ramsbottom reported that out of the grant sanctioned at the Keswick meeting he had purchased for the Society Grove's *British Rust Fungi* and that he had arranged for copies of all the British Museum publications on fungi, lichens and mycotozoa to be presented to the Society. Further, Mr Sharpe had given Massee's *British Fungus Flora*. A further grant up to £10 was sanctioned for the purpose of buying books.

Sunday, as usual, was left free for members to do as they pleased. Most went off in various groups and explored parts of Windsor Great Park, with the result that some extremely interesting species were found. On the fine old elms near the entrance two fungi which were new to most members were discovered, namely, *Polyporus spumeus* and *Pleurotus pantoleucus*. *Polyporus spumeus* grew from the wounds where large branches had been cut off, and when grasped in order to cut it away it was found to exude water exactly like a wet sponge. Other interesting species gathered in Windsor Park were *Collybia longipes* var. *badia*, *Omphalia velutina*, *Cortinarius dolabratus*, *Inocybe rhodiola*, and *Hebeloma longicaudum*.

In the evening Mr Brooks gave his paper on "Epidemic Plant Diseases*," an extremely useful summary of the nature, causes, and conditions of epidemic diseases.

Burnham Beeches, visited on Monday, proved a rich hunting-ground. Among the more rare and noteworthy species obtained were *Amanita porphyria*, *A. nitida*, *Pleurotus lignatilis*, *Cantharellus tubaeformis*, *Rozites caperatus*, *Inocybe pyriodora*, *Cortinarius triumphans*, *C. arvinaceus*, *C. argentatus*, *C. armillatus*, *C. saturninus*, *Hydnum coralloides*, and *H. erinaceus*.

In the evening the President, Professor O. V. Darbishire, delivered his Presidential Address on "Lichenology," a summary of the history and present position of the subject.

Two localities were included in the foray on the Tuesday, Brockhurst Wood and Stoke Common. The former in particular provided some additional records of interest, such as *Tricholoma cinerascens*, *Panus torulosus*, *Leptonia cuchroa*, *Cortinarius claricolor*, *C. decoloratus*, *C. uliginosus*, *Stropharia caput-Medusae*, and *Diatrypella favacea* on birch.

In the evening Mr Carleton Rea gave an informal talk on the chief species found during the foray. A short communication

* See vol. IX, p. 228.

by the late Sir H. C. Hawley enumerated fourteen species of fungi found in August on a blackbird's nest*. Mr J. Ramsbottom gave a short paper on "Mushrooms and Toadstools" which had been broadcasted a few days previously.

Wednesday proved to be most uncompromisingly wet, but in spite of the fact that the rain started in the morning a charabanc load of brave spirits set out for Black Park, Langley, hoping that the weather would clear later. The hope proved unfounded, however, and search had soon to be given up. What little was done yielded some species of interest, which showed that the locality might have proved a rich one.

At the start the members proceeded to get rid of sandwiches in the shelter of a wood-shed, and from there at once observed a fallen elm quite covered with very fine specimens of *Pleurotus sapidus*, a species which had also been found in Windsor Park and at Burnham Beeches. A search in the wood-yard revealed *Coprinus picaceus*, and on a sawdust heap near the lake *Pluteus cervinus* var. *Bullii* and *P. eximius* were discovered. Other interesting finds were *Leptonia incana*, *Psilocybe canobrunnea*, and a curiously distorted form of *Polyporus betulinus*, apparently parasitised by some other fungus, which, however, could not be recognised.

In the evening the few members left enjoyed a short account given by Mr Ramsbottom of an attempted but unpublished monograph on Discomycetes by Dr M. C. Cooke.

The meeting closed with the usual votes of thanks to landowners, and in particular a very hearty vote of thanks was given to Mr Buckley, who had arranged the various excursions and acted as leader.

For assistance in compiling the subjoined list the Secretary is indebted to all members present, and in particular to Mr Carleton Rea, Mr Ramsbottom, Mr Buddin, Mr Grinling and Dr Bayliss Elliott.

List of Species gathered during the Foray.

V = Virginia Water; *W* = Windsor Park; *B* = Burnham Beeches; *S* = Stoke Common; *T* = Brockhurst Wood; *P* = Black Park, Langley.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr., *V.*, *B.*, *T.*, *S.*, porphyria (A. & S.) Fr., *B.*, *T.*, mappa (Batsch) Fr., *V.*, *T.*, *P.*, and var. alba (Gill.) Rea, *V.*, *T.*, *P.*, muscaria (Linn.) Fr., *V.*, *B.*, *T.*, *S.*, spissa Fr., *V.*, *T.*, rubescens (Pers.) Fr., *V.*, *B.*, *T.*, nitida Fr., *B.*

Amanitopsis vaginata (Bull.) Roze, *V.*, fulva (Schaeff.) W. G. Sm., *V.*, *B.*, *S.*

Lepiota procera (Scop.) Fr., *W.*, rhacodes (Vitt.) Fr., *V.*, *W.*, felina (Pers.) Fr., *P.*, amaianthina (Scop.) Fr., *V.*, *T.*

Armillaria mellea (Vahl) Fr., *W.*, *V.*, *B.*, *T.*, *P.*, mucida (Schrad.) Fr., *B.*, *W.*, *T.*

Tricholoma fulvum (DC.) Fr., *W.*, *T.*, rutilans (Schaeff.) Fr., *V.*, *T.*, terreum (Schaeff.) Fr., *B.*, *T.*, cuneifolium Fr., *B.*, carneum (Bull.) Fr., *W.*, per-

* See vol. IX, p. 239.

sonatum Fr., *W.*, *B.*, glaucocanum Bres., *W.*, cinerascens (Bull.) Quél., *T.*, porphyroleucum (Bull.) Fr., *W.*

Clitocybe nebularis (Batsch) Fr., *T.*, *P.*, clavipes (Pers.) Fr., *T.*, *P.*, *V.*, aurantiaca (Wulf.) Studer, *V.*, *B.*, *T.*, rivulosa (Pers.) Fr., *W.*, cerussata Fr., *W.*, infundibuliformis (Schaeff.) Fr., *W.*, *V.*, geotropa (Bull.) Fr., *V.*, *W.*, flaccida (Sow.) Fr., *W.*, *P.*, suaveolens (Schum.) Fr., *T.*, brumalis Fr., *B.*, metachroa (Fr.) Berk., *V.*, ditopus Fr., *S.*, fragrans (Sow.) Fr., *W.*

Laccaria laccata (Scop.) B. & Br., and var. amethystina (Vaill.) B. & Br., *W.*, *V.*, *B.*, *T.*, *P.*

Collybia radicata (Relh.) Berk., *B.*, *T.*, longipes (Bull.) Berk. var. badia Lucand, *W.*, platyphylla (Pers.) Fr., *W.*, *B.*, fusipes (Bull.) Berk., *W.*, *B.*, maculata (A. & S.) Fr., *W.*, *V.*, *T.*, *B.*, butyracea (Bull.) Fr., *V.*, *T.*, cirrhata (Schum.) Fr., *B.*, tuberosa (Bull.) Fr., *V.*, *T.*, acervata Fr., *V.*, inolens Fr., *V.*, atrata Fr., *V.*, ambusta Fr., *W.*

Mycena pura (Pers.) Fr., *V.*, Adonis (Bull.) Fr., *B.*, flavo-alba Fr., *W.*, rugosa Fr., *V.*, *W.*, *B.*, *P.*, galericulata (Scop.) Fr., *V.*, *B.*, polygramma (Bull.) Fr., *V.*, *B.*, inclinata Fr., *W.*, *B.*, *T.*, ammoniaca Fr., *V.*, *B.*, *W.*, *T.*, *P.*, vitilis Fr., *B.*, sanguinolenta (A. & S.) Fr., *V.*, galopus (Pers.) Fr., *V.*, *T.*, *B.*, and var. nigra Fl. Dan., *V.*, *T.*, epipterygia (Scop.) Fr., *B.*, *T.*, stylobates (Pers.) Fr., *W.*

Omphalia pyxidata (Bull.) Fr., *W.*, *V.*, umbellifera (Linn.) Fr. var. citrina Quél., *B.*, velutina Quél., *W.*, fibula (Bull.) Fr., *T.*

Pleurotus corticatus Fr., *V.*, *W.*, lignatilis Fr., *B.*, sapidus Schulz., *W.*, *B.*, *P.*, pantoleucus Fr., *W.*, ostreatus (Jacq.) Fr., *T.*, revolutus Kick., *T.*, acerosus Fr., *V.*

Hygrophorus eburneus (Bull.) Fr., *B.*, cossus (Sow.) Fr., *T.*, coccineus (Schaeff.) Fr., *V.*, miniatus Fr., *T.*, chlorophanus Fr., *V.*, psittacinus (Schaeff.) Fr., *V.*, unguinosus Fr., *V.*

Lactarius turpis (Weinm.) Fr., *V.*, *B.*, *S.*, pubescens Fr., *V.*, *T.*, insulsus Fr., *W.*, blennius Fr., *V.*, *W.*, *T.*, circellatus Fr., *B.*, chrysorheus Fr., *V.*, *B.*, *T.*, *P.*, vellereus Fr., *W.*, *B.*, quietus Fr., *B.*, *T.*, *V.*, aurantiacus (Fl. Dan.) Fr., *B.*, theiogalus (Fr.) Plowr., *V.*, *T.*, *P.*, vietus Fr., *B.*, rufus (Scop.) Fr., *T.*, *P.*, glyciosmus Fr., *W.*, *B.*, serifluus (DC.) Fr., *B.*, *T.*, *P.*, subdulcis (Pers.) Fr., *V.*, *B.*, *T.*, *P.*, cimicarius (Batsch) Cooke, *V.*

Russula chloroides (Krombh.) Bres., *W.*, nigricans (Bull.) Fr., *V.*, *W.*, *T.*, adusta (Pers.) Fr., *T.*, incarnata Quél., *T.*, lepida Fr., *V.*, *W.*, azurea Bres., *V.*, cyanoxantha (Schaeff.) Fr., *V.*, *B.*, *S.*, furcata (Pers.) Fr., *V.*, *B.*, *S.*, *T.*, pectinata (Bull.) Fr., *W.*, ochroleuca (Pers.) Fr., *V.*, *W.*, *B.*, *T.*, *P.*, fellea Fr., *V.*, *B.*, *T.*, fragilis (Pers.) Fr., *W.*, *V.*, *B.*, *T.*, and var. fallax (Schaeff.) Mass., *W.*, *V.*, emetica (Schaeff.) Fr., *W.*, *V.*, *B.*, *T.*, *P.*, atropurpurea (Krombh.) Maire, *W.*, *B.*, *T.*, integra (Linn.) Bat., *W.*, xerampelina (Schaeff.) Fr., *V.*, vesca Fr., *W.*, *V.*, punctata (Gill.) Maire, *W.*, mustelina Fr., *W.*, *T.*, lutea (Huds.) Fr., *V.*, and var. armeniaca (Cooke) Rea, *W.*, *B.*, *T.*

Cantharellus cibarius Fr., *W.*, *V.*, *T.*, *P.*, carbonarius (A. & S.) Fr., *S.*, tubaeformis Fr., *B.*, *T.*, infundibuliformis (Scop.) Fr., *T.*

Marasmius peronatus (Bolt.) Fr., *W.*, *V.*, *T.*, oreades (Bolt.) Fr., *W.*, erythropus (Pers.) Fr., *W.*, *P.*, hariolorum (DC.) Quél., *V.*, dryophilus (Bull.) Karst., *W.*, *S.*, and var. aquosus (Bull.) Rea, *V.*, ramealis (Bull.) Fr., *T.*

Androsaceus androsaceus (Linn.) Pat., *V.*, *T.*

Panus torulosus (Pers.) Fr., *T.*, stypticus (Bull.) Fr., *T.*

Lenzites betulina (Linn.) Fr., *T.*, saepiaria (Wulf.) Fr., *V.*

Pluteus cervinus (Schaeff.) Fr., *W.*, *V.*, *T.*, *P.*, and var. Bullii Berk., *P.*, eximius Saund. & Sm., *P.*, umbrosus (Pers.) Fr., *V.*

Entoloma rhodopolium Fr., *W.*, *T.*, sericeum (Bull.) Fr., *W.*, *V.*, *T.*, nidorosum Fr., *B.*, *S.*

Nolanea pascua (Pers.) Fr., *W.*, *V.*, *T.*

Leptonia euchroa (Pers.) Fr., *T.*, incana Fr., *P.*, sericella (Fr.) Quél., *W.*

Eccilia rhodocylix (Lasch) Fr., *W.*

Pholiota togularis (Bull.) Fr., *W.*, dura (Bolt.) Fr., *T.*, radicosa (Bull.) Fr., *B.*, squarrosa (Müll.) Fr., *W.*, spectabilis Fr., *V.*, *P.*, mutabilis (Schaeff.) Fr., *T.*, marginata (Batsch) Fr., *T.*

Rozites caperatus (Pers.) Karst., *B.*
Inocybe pyriodora (Pers.) Fr., *W.*, *B.*, rimosa (Bull.) Fr., *W.*, geophylla (Sow.) Fr., *W.*, *V.*, cervicolor (Pers.) Quél., *V.*, cincinnata Fr., *T.*, rhodiola Bres., *W.*, fastigiata (Schaeff.) Fr., *W.*, *V.*
Astrosporina proximella (Karst.) Rea, *W.*, *V.*, asterospora (Quél.) Rea, *V.*, sabuletorum (B. & C.) Rea, *V.*, *S.*, petiginosa (Fr.) Rea, *T.*
Hebeloma fastibile Fr., *V.*, *W.*, *S.*, glutinosum (Lindgr.) Fr., *W.*, mesophaeum Fr., *W.*, crustuliniforme (Bull.) Fr., *T.*, and var. minus Cke, *W.*, *B.*, longicaudum (Pers.) Fr., *W.*
Flammula lubrica (Pers.) Fr., *V.*, gummosa (Lasch) Fr., *W.*, carbonaria Fr., *V.*, *T.*, *P.*, flavida (Schaeff.) Fr., *B.*, sapinea Fr., *V.*, *T.*, *P.*, ochrochlora Fr., *P.*
Naucoria melinoides Fr., *B.*, conspersa (Pers.) Fr., *B.*, *T.*, escharoides Fr., *V.*
Galera tenera (Schaeff.) Fr., *W.*, hypnorum (Schrank) Fr., *V.*, *T.*, *S.*
Tubaria furfuracea (Pers.) W. G. Sm., *W.*, paludosa Fr., *V.*, *T.*, inquilina (Fr.) W. G. Sm., *W.*, *T.*
Crepidotus alveolus (Lasch) Fr., *W.*
Cortinarius (Phlegmacium) triumphans Fr., *B.*, claricolor Fr., *V.*, *T.*, decoloratus Fr., *W.*, *T.*
— (Myxacium) arvinaceus Fr., *B.*, collinitus (Sow.) Fr., *W.*, *T.*, mucosus (Bull.) Fr., *T.*, elatior Fr., *V.*, *B.*, *T.*
— (Inoloma) argentatus (Pers.) Fr., *B.*, pholideus Fr., *V.*
— (Dermocybe) caninus Fr., *V.*, *T.*, anomalus Fr., *V.*, semisanguineus (Brig.) Maire, *W.*, *B.*, sanguineus (Wulf.) Fr., *B.*, cinnamomeus (Linn.) Fr., *B.*, uliginosus Berk., *T.*
— (Telamonia) torvus Fr., *V.*, *T.*, armillatus Fr., *B.*, hinnuleus (Sow.) Fr., *B.*, *T.*, brunneus (Pers.) Fr., *P.*, incisus (Pers.) Fr., *W.*, *B.*, hemitrichus Fr., *V.*, *B.*, *T.*, rigidus (Scop.) Fr., *V.*, *T.*
— (Hydrocybe) saturninus Fr., *B.*, castaneus (Bull.) Fr., *B.*, *P.*, dolabratus Fr., *W.*, leucopus (Bull.) Fr., *T.*, decipiens (Pers.) Fr., *V.*, acutus (Pers.) Fr., *B.*
Paxillus involutus (Batsch) Fr., *W.*, *V.*, *B.*, *T.*, atro-tomentosus (Batsch) Fr., *V.*
Psaliota Elvensis B. & Br., *W.*, campestris (Linn.) Fr., *W.*, *V.*
Stropharia aeruginosa (Curt.) Fr., *W.*, *V.*, *T.*, squamosa (Pers.) Fr., *V.*, *B.*, *T.*, semiglobata (Batsch) Fr., *V.*, *W.*, *B.*, *T.*, caput-Medusae Fr., *T.*
Hypholoma sublateritium (Schaeff.) Fr., *V.*, epixanthum Fr., *W.*, fasciculare (Huds.) Fr., *V.*, *T.*, lacrymabundum Fr., *T.*, appendiculatum (Bull.) Fr., *B.*, *T.*, *P.*, leucotephrum B. & Br., *B.*, hydrophilum (Bull.) Fr., *W.*, *B.*, *P.*
Psilocybe ericaea (Pers.) Fr., *B.*, uda (Pers.) Fr., *V.*, *S.*, bullacea (Bull.) Fr., *V.*, *T.*, semilanceata Fr., *V.*, *T.*, canobrunnea (Batsch) Fr., *P.*, spadicea Fr., *T.*
Psathyra pennata Fr., *V.*, *B.*, *T.*, *S.*
Bolbitius titubans (Bull.) Fr., *T.*
Coprinus comatus (Fl. Dan.) Fr., *W.*, atramentarius (Bull.) Fr., *W.*, picaceus (Bull.) Fr., *P.*, cinereus (Schaeff.) Cke, *W.*, *V.*, *T.*, niveus (Pers.) Fr., *W.*, micaceus (Bull.) Fr., *W.*, *P.*, domesticus (Pers.) Fr., *S.*, plicatilis (Curt.) Fr., *V.*, *T.*
Panaeolus sphinctrinus Fr., *W.*, *T.*, campanulatus (Linn.) Fr., *V.*, *T.*, *B.*
Psathyrella gracilis Fr., *T.*, atomata Fr., *W.*, *S.*, disseminata (Pers.) Fr., *V.*, *B.*
Gomphidius glutinosus (Schaeff.) Fr., *V.*, viscidus (Linn.) Fr., *T.*
Boletus elegans (Schum.) Fr., *T.*, badius Fr., *V.*, *B.*, *T.*, bovinus (Linn.) Fr., *B.*, variegatus (Swartz) Fr., *T.*, chrysenteron (Bull.) Fr., *V.*, *B.*, *T.*, *P.*, subtomentosus (Linn.) Fr., *V.*, *T.*, pruinatus Fr., *V.*, *P.*, pinicola (Vitt.) Rea, *V.*, reticulatus (Schaeff.) Boud., *V.*, *T.*, aestivalis (Paul.) Fr., *W.*, luridus (Schaeff.) Fr., *V.*, *T.*, versipellis Fr., *V.*, *B.*, *T.*, scaber (Bull.) Fr., *V.*, *B.*, *T.*, *S.*
Fistulina hepatica (Huds.) Fr., *W.*, *T.*
Polyporus perennis (Linn.) Fr., *W.*, *S.*, squamosus (Huds.) Fr., *W.*, *V.*, *P.*, intybaceus Fr., *B.*, *P.*, Schweinitzii Fr., *V.*, *T.*, *P.*, giganteus (Pers.) Fr., *W.*, betulinus (Bull.) Fr., *P.*, dryadeus (Pers.) Fr., *W.*, adiposus B. & Br., *V.*, *B.*, adustus (Willd.) Fr., *V.*, *T.*, caesius (Schrad.) Fr., *T.*, spumeus (Sow.) Fr., *W.* (on *elm*).

Fomes ulmarius (Sow.) Fr., *W.*, annosus Fr., *V.*
Ganoderma applanatum (Pers.) Pat., *W.*, and var. laccatum (Kalchbr.) Rea, *W.*
Polystictus versicolor (Linn.) Fr., *T.*
Poria mollusca (Pers.) Fr., *V.*
Trametes gibbosa (Pers.) Fr., *V.*, *T.*, rubescens (A. & S.) Fr., *B.*, *T.*
Daedalea biennis (Bull.) Quél., *W.*, quercina (Linn.) Fr., *B.*
Merulius tremellosus (Schrad.) Fr., *W.*, *V.*, *B.*
Phlebia merismoides Fr., *W.*, *B.*, *T.*
Hydnum repandum (Linn.) Fr., *B.*, *T.*, coralloides (Scop.) Fr., *B.*, erinaceus (Bull.) Fr., *B.*
Acia uda (Fr.) Bourd. & Galz., *T.*
Irpex obliquus (Schrad.) Fr., *V.*
Odontia farinacea (Pers.) Quél., *V.*
Craterellus cornucopioides (Linn.) Fr., *T.*
Thelephora terrestris (Ehrb.) Fr., *V.*, *B.*
Hypochnus fuscus (Pers.) Fr., *V.*, *T.*, fumosus Fr., *V.*
Stereum multizonatum (B. & Br.) Mass., *W.*, rugosum (Pers.) Fr., *V.*, hirsutum (Willd.) Fr., *T.*, *S.*, purpureum (Pers.) Fr., *W.*, *B.*
Sparassis crispa (Wulf.) Fr., *V.*, *B.*, *P.*
Hymenochaete rubiginosa (Dicks.) Lév., *B.*, *T.*
Corticium laeve (Pers.) Fr., *B.*, *T.*, arachnoideum Berk., *V.*, subcoronatum v. H. & Litsch., *V.*
Peniophora Aegerita v. H. & Litsch., *T.*, cremea Bres., *V.*, setigera (Fr.) Bres., *V.*, *B.*, aurantiaca (Bres.) B. & G., *B.*, cinerea (Fr.) Cke, *V.*, quercina (Pers.) Cke., *V.*
Coniophora puteana (Schum.) Karst., *V.*, *W.*, arida Fr., *P.*
Solenia anomala (Pers.) Fr., *B.*
Clavaria cristata (Holmsk.) Fr., *V.*, *B.*, cinerea (Bull.) Fr., *V.*, rugosa (Bull.) Fr., *B.*, stricta (Pers.) Fr., *S.*, *T.*, inaequalis (Müll.) Fr., *V.*
Typhula erythropus (Bolt.) Fr., *B.*
Pistillaria quisquiliaris Fr., *B.*
Auricularia mesenterica (Dicks.) Fr., *P.*, auricula-Judae (Linn.) Schroet., *V.*
Tremella mesenterica (Retz.) Fr., *V.*
Tremellodon gelatinosum (Scop.) Pers., *V.*, *T.*
Dacryomyces deliquescens (Bull.) Duby, *V.*
Calocera viscosa (Pers.) Fr., *V.*, *B.*, stricta Fr., *T.*, *P.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *W.*, *V.*, *T.*
Mutinus caninus (Huds.) Fr., *B.*, *P.*
Sphaerobolus stellatus (Tode) Pers., *V.*, *B.*, *T.*
Crucibulum vulgare Tul., *V.*
Lycoperdon depressum Bon., *V.*, umbrinum Pers., *V.*, *B.*, perlatum Pers., *V.*, *B.*, *T.*, *P.*, pyriforme (Schaeff.) Pers., *W.*, *T.*
Scleroderma vulgare Hornem., *W.*, *V.*, *S.*

UREDINEAE.

Uromyces Valerianae (Schum.) Fckl., *B.*
Puccinia Violae (Schum.) DC., *V.*, Menthae Pers., *V.*, obscura Schroet., *T.*, Caricis (Schum.) Rebent., *V.*
Phragmidium Fragariae (DC.) Wint., *V.* on *Potentilla erecta*, *V.*, subcorticium (Schrank) Wint., *V.*, Rubi (Pers.) Wint., *V.*
Pucciniastrum Epilobii (Pers.) Otth., *V.*, *B.*, *T.*
Melampsoridium betulinum (Pers.) Kleb., *V.*, *B.*, *T.*

USTILAGINEAE.

Ustilago longissima (Sow.) Tul., *V.*
Sphacelotheca Hydropiperis (Schum.) de By., *W.*

DISCOMYCETES.

Aleuria Emileia (Cooke) Boud., *V.*
Otidea onotica (Pers.) Fuck., *T.*

Peziza aurantia Pers., *B.*, rutilans Fr., *B.*
Leotia lubrica (Scop.) Pers., *W.*
Cudoniella acicularis (Bull.) Schroet., *B.*, *T.*
Bulgaria inquinans (Pers.) Fr., *T.*
Calycella lenticularis (Bull.) Boud., *V.*, sublenticularis (Fr.) Boud., *B.*, ferruginea (Schum.) Boud., *B.*
Orbilia xanthostigma Fr., *V.*, *B.*
Sclerotinia Curreyana (Berk.) Karst., *B.*
Stromatinia pseudotuberosa (Rehm) Boud., *V.*
Phialea firma (Pers.) Gill., *B.*
Helotium herbarum (Pers.) Fr., *B.*
Dasyscypha virginea (Batsch) Fuck., *B.*, luteola (Curr.) Sacc., *S.*, ciliaris (Schrad.) Sacc., *B.*, fuscescens (Pers.) Rehm, *B.*
Trichoscypha calycina (Schum.) Boud., *V.*
Mollisia cinerea (Batsch) Karst., *V.*, *B.*
Tapesia fusca (Pers.) Fuck., *V.*
Stegia Ilicis Fr., *T.*
Rhytisma acerinum (Pers.) Fr., *V.*

PYRENOMYCETES.

Uncinula Aceris (DC.) Sacc., *V.*
Erysiphe Polygoni DC. (on *clover*), *W.*
Nectria cinnabarina (Tode) Fr., *V.*, *T.*
Hypomyces rosellus Tul., *P.*
Cordyceps militaris (Linn.) Link, *V.*
Claviceps microcephala (Wallr.) Wint., on *Molinia, Dactylis* and *Lolium, W.*, *B.*, *T.*
Leptospora ovina (Pers.) Fuck., *B.*
Melanomma pulvis-pyrius (Pers.) Fuck., *B.*
Leptosphaeria Doliolum (Pers.) Ces. & de Not., *B.*
Melanconis stilbostoma (Fr.) Tul., *B.*
Diatrype disciformis (Hoffm.) Fr., *V.*
Diatrypella favacea (Fr.) de Not., *T.*
Hypoxylon coccineum Bull., *T.*
Xylaria Hypoxylon (Linn.) Grev., *W.*, *V.*, *T.*
Dothidella Ulmi (Duv.) Wint., *V.*
Dichaena quercina Fr., *B.*
Rhopographus Pteridis (Sow.) Wint., *B.*

PHYCOMYCETES.

Spinellus fusiger (Link) van Tiegh., *V.*
Syzygites megalocarpus Ehrb., *V.*

SPHAEROPSIDEAE.

Septoria Rubi West., *V.*, *B.*
Libertella faginea Desm., *B.*

HYPHOMYCETES.

Cylindrium aeruginosum (Link) Lindau, *B.*
Oidium alphitoides Griff. & Maubl., *V.*, *B.*, *T.*, *S.*
Ovularia obliqua (Cooke) Oud., *B.*, *T.*
Botrytis Tilletii Desm., *V.*
Ramularia calcea (Desm.) Ces., *V.*, Knautiae (Mass.) Bub., *T.*, Lampsanae (Desm.) Sacc., *B.*
Rhinotrichum repens Preuss, *V.*, Thwaitesii B. & Br., *T.*
Sepedonium chrysospermum (Bull.) Fr., *T.*
Menispora ciliata Corda, *B.*
Bispora monilioides Corda, *T.*
Isaria farinosa Fr., *B.*

MYCETOZOA OF THE WINDSOR FORAY.

By G. Lister, F.L.S.

On September 29th the party visited Virginia Water, where the timber consists of Beech, Spanish Chestnut, Oak, Scotch Fir, Spruce and Holly, with some undergrowth of Rhododendron. Fine old stumps of Silver Fir and Spruce yielded large quantities of *Tubifera ferruginosa*, young and old; in the hollow of a large stump was abundance of *Hemitrichia Vesparium*, associated with *Trichia floriformis*, a species not common in Britain. On October 1st the party drove to near Burnham Beeches, visiting first a moor from which timber had been cleared. Here wide stretches of the moss *Campylopus pyriformis* were searched in vain for *Colloderma oculatum*, an inconspicuous species often found in such a habitat; cushions of the moss were, however, brought away and kept moist, and on them sporangia of *Colloderma* first appeared on October 23rd, and continued to emerge to the number of forty until December 8th, when the moss became disturbed by burrowing grubs. On October 2nd Brockhurst Woods and Stoke Common were searched. A small plantation of Scotch Fir yielded, among other species, *Comatricha fimbriata*, a minute form not recorded before for Buckinghamshire. Heaps of faggots and sticks proved the rich hunting ground; here amongst other kinds were found the plasmodium of *Badhamia utricularis* which afterwards developed into sporangia, and many small aethalia of *Enteridium olivaceum*. The total number of Mycetozoa found during the foray was thirty-seven.

Ceratiomyxa fruticulosa (Mueller) Macbr., *V.*
Badhamia utricularis (Bull.) Berk., *S., T.*
Physarum nutans Pers., *V., B., S., T.*
P. viride (Bull.) Pers., *V., B., S., T.*
P. compressum Alb. & Schw., *S., T.*
Fuligo septica (L.) Gmel., *V., B., S., T.*
F. muscorum Alb. & Schw., *V.*
Craterium minutum (Leers) Fries, *V.*
C. leucocephalum Ditm., *V.*
Diderma spumarioides Fries, *V.*
Didymium difforme (Pers.) Duby., *S., T.*
D. squamulosum (Alb. & Schw.) Fries, *B., S., T.*
D. Clavus (Alb. & Schw.) Rab., *S., T.*
Colloderma oculatum (Lipp.) G. Lister, *B.*
Stemonitis fusca Roth., *V., B.*, and var. confluens Lister, *V.*
S. hyperopta Meyl. (syn. Comatricha typhoides var. heterospora Rex), *V.*
Comatricha nigra (Pers.) Schroet., *V., B.*
C. fimbriata G. Lister & Cran., *S., T.*
C. typhoides (Bull.) Rost., *V.*
Cribraria argillacea Pers., *V.*
C. vulgaris Schrad., *V., B., S., T.*
Licea flexuosa Pers., *V., B.*
Tubifera ferruginosa Gmel., *V., B.*
Reticularia Lycoperdon Bull., *V., B.*
Enteridium olivaceum Ehrenb., *S., T.*
Lycogala epidendrum (L.) Fr., *S., T.*
Trichia persimilis Karst., *V.*
T. scabra Rost., *V.*
T. varia Pers., *V., B., S., T.*

T. Botrytis Pers. var. flavicoma Lister, *S.*, *T.*
T. floriformis (Schwein.) G. Lister, *V.*
Hemitrichia Vesparium (Batsch) Macbr., *V.*
Arcyria cinerea (Bull.) Pers., *S.*, *T.*
A. pomiformis (Leers) Rost., *V.*, *B.*
A. denudata (L.) Wettst., *V.*, *B.*, *S.*, *T.*
A. incarnata Pers., *B.*, *S.*, *T.*
A. nutans (Bull.) Grev., *V.*, *B.*

LICHENS OF THE WINDSOR FORAY.

By H. H. Knight, M.A.

CORTICOLOUS Lichens were not plentiful in this district, and common species like *Parmelia* and *Evernia prunastri* were often poorly developed. Saxicolous Lichens were found mostly on stone or brick walls, but three species of Lecanora, *L. parella*, *L. atra* and *L. sulphurea* were growing on sandstone rocks at Virginia Water. The sandy soil was suitable for some of the terricolous Lichens, as species of *Cladonia*, and *Lecidea granulosa* and *uliginosa*. In the case of some of the common species no locality is given.

Chaenotheca melanophaea Zwackh., *B.*
Cyphelium inquinans Trev., *W.*
Peltigera canina Willd., *V.*
P. polydactyla Hoffm., *V.*
Parmelia physodes Ach.
P. caperata Ach., *B.*
P. saxatilis Ach., *W.*
P. sulcata Tayl.
P. dubia Tayl., *W.*
P. fuliginosa Nyl. var. laetevirens Nyl., *B.*
Evernia prunastri Ach., *B.*
Xanthoria parietina Th. Fr.
X. lychnea Th. Fr., *W.*
Placodium murorum DC., *W.*
P. luteo-album Hepp., *W.*
Candelariella vitellina Müll.-Arg., *W.*
Physcia pulverulenta Nyl., *W.*
P. hispida Tuckerm., *W.*
P. caesia Nyl., *W.*
P. orbicularis Dal. Tor. & Sarnth. var. virella Dal. Tor. & Sarnth., *W.*
Rinodina demissa Arn., *V.*
Lecanora muralis Schaer. on bridge at Eton.
L. subfusca Ach., *B.*
L. rugosa Ach., *V.*
L. campestris B. de Lesd., *W.*
L. atra Ach., *V.*
L. Hageni Ach., *W.*
L. galactina Ach., *W.*
L. varia Ach.
L. sulphurea Ach., *V.*
L. parella Ach., *V.*
Lecania erysibe Mudd, *V.*, *W.*
Pertusaria faginea Leight.
P. pertusa Dal. Tor. & Sarnth.
Baeomyces rufus DC., *B.*
Cladonia sylvatica Hoffm., *T.*
C. pyxidata Hoffm., *B.*
C. fimbriata Fr.
C. furcata Schrad., *B.*
C. digitata Hoffm., *B.*
C. macilenta Hoffm., *B.*
C. Floerkeana Fr., *B.*
Lecidea ostreata Schaer., *W.*
L. quernea Ach., *V.*
L. granulosa Schaer., *V.*, *B.*
L. uliginosa Ach., *V.*, *B.*
L. fuliginea Ach., *V.*
Biatorina Griffithii Massal., *V.*
Buellia canescens De Not.
B. myriocarpa Mudd
Opegrapha varia Pers., *W.*
Graphis elegans Ach., *B.*, *T.*
Enterographa crassa Fée, *V.*

PRESIDENTIAL ADDRESS.

(With 1 Text-fig.)

By Prof. O. V. Darbishire.

SOME ASPECTS OF LICHENOLOGY.

About one hundred years ago on January 2nd, 1822, there was born, at Uleaborg in Finland, William Nylander (11) who was to become a great lichen-systematist. He qualified as a doctor, and in 1847 wrote his first paper on lichens. From 1857 to 1863 he acted as professor of Botany at Helsingfors, paying during that time, however, frequent botanical visits to Paris. He ultimately settled down there to devote his whole time and energy to the detailed study of lichens, and died in March 1899. He was in many respects a typical representative of the lichenologists of the nineteenth century, and for many years was to many lichenologists the last court of appeal in the case of doubtful species. Although he published his first paper in 1847, his last contribution to lichenology was not made till 1898, after a period of fifty-one years of ceaseless hard work. He had in Paris wonderful opportunities for working through lichen-material brought together from all parts of the world, and he made full use of these opportunities, thereby acquiring a deep knowledge of lichen-species and lichen-genera. At first strongly opposed to the "splitting" of species, he later became just the reverse, perhaps a not uncommon occurrence with many systematists. He evolved a system of classification (12, p. 11) which may have some adherents even now. At one end of his system the Ephebacei and Collemacei passed into the algae and at the other the Pyrenocarpei were connected with the fungi. This artificial system has long been replaced by a more natural one. Nothing in fact remains of Nylander's work but a host of species and genera of which he is the author, and many of his species are a sore trial to lichenologists of to-day. A large number are no longer decipherable, though there is no doubt that he knew his species well and they were generally good species. But he named new species with a total disregard for the equally good work of those of his contemporaries who did not follow him absolutely. There can unfortunately be no doubt that on this account many species of the last century have at least two names apart from the usual synonyms. At the same time, Nylander's services to lichenology were very great. He very fully appreciated the value of generic differences, though to many genera of to-day he gave only the rank of sub-genera. His descriptions, however, were generally very brief and only very rarely accompanied by figures.

Seven years after the birth of Nylander, on February 10th, 1829, there was born in Switzerland, Simon Schwendener (6), who died as late as May 1919, at the advanced age of 90. Schwendener became Assistant to Naegeli at Munich in 1857 and held a University post for the rest of his life. To him was due the formulation in 1867 of the theory of the dual nature of lichens (23). He came to this result in the course of a careful study and comparative survey of the structure of lichens, begun in 1860 and completed in 1868 (22). His theory immediately met with much opposition, which has not even yet completely died down. The refusal to accept Schwendener's theory at first came mainly from lichen-systematists and was due to the fear that with its acceptance the autonomous group of lichens would disappear and the various genera would be relegated to places amongst the algae or fungi. Opposition was not originally based on any experimental evidence or extensive microscopical research. Latterly, however, Elfving (10) has again attempted to show that gonidial cells, which we generally now consider to be algae, are derived really from the colourless hyphae which we regard as fungi. Elfving's work has been carried out with great care and should receive equally careful consideration.

I like to compare and contrast these two men—Nylander and Schwendener. The former a systematist, pure and simple, rather narrow-minded, and towards the end of his life very soured and almost a recluse in his home life and in his work. He wrote very bitterly against Schwendener, whose theory he absolutely refused to accept. His work is unknown to the ordinary botanist. On the other hand, we have Schwendener who—one might almost say—merely dabbled in lichenology, yet completely changed our ideas as to the nature of lichens and thus rendered a great service to Botany generally. All subsequent physiological and systematic work on lichens is based on Schwendener's theory of the dual nature of the lichen thallus. Schwendener really did little more than examine anatomically a large number of lichens, and the clear insight he thus obtained turned his thoughts to a special study of the colourless hyphae in their relation to the green gonidia, whose likeness to free algae struck him. He found an explanation for this similarity in the discovery that they were algae imprisoned by a fungus. Having settled this matter, he left the lichens and went on to the higher plants. Lichens differ so much from algae and fungi that, in spite of Schwendener's theory, there can be no question of relegating the lichens to their nearest relatives among the algae and fungi.

Nylander and Schwendener held two totally different points of view, and there was at first no co-operation between the two groups of workers of which they may be said to be representative. We will see later how far this is still the case.

Systematic lichenology has at the present moment reached such a state that it can only be saved by the monographing of families, genera and even species. This will probably have to be accompanied by the wholesale dropping of many old names. In order to be sure of our species and their distribution it will be necessary to bring together and examine critically typical representatives of one species from all over the world in order to correlate the interpretations by various authors of such a species. Dr A. Zahlbruckner of Vienna has been publishing since 1922 a Catalogus Lichenum Universalis(31) of which Volume I has appeared and the second volume is nearing completion. It will contain a complete list of lichen-species and their synonymy and references to literature, but it is not a critical revision of the species or genera. It does not contain descriptions of species but is merely a guide to the best descriptions and the most important Exsiccata. It should form an invaluable aid to any monographer, and I hope will encourage those who have the necessary opportunity and patience to embark on a monograph of some genus or species. If carried through carefully the worker would be well rewarded, as he would find such an undertaking full of interest. Let us take only one well-known species, *Lecanora subfusca* (L.) Ach. Do all the specimens referred to by this name belong to the same species, whether collected in America, Africa, the Arctic or Antarctic continent, Europe or Asia and so on, disregarding for the moment the vexed question as to what a species really is? *Lecanora subfusca* also changes its appearance and structure completely according as to whether it grows on wood or stone, and includes endless varieties and "sub-species." Such a monograph would be of the greatest interest too from a phyto-geographical point of view, and it is not unlikely that it might also help to explain some difficulties encountered in the distribution of the higher plants. Many Arctic species of lichens are recorded for the Antarctic continent. On the other hand, in the Roccellei the species found in America are not met with in the Old World. A monograph of this family(8) was necessary before this was made clear.

It is often very difficult to define and separate lichen-species. In the higher plants we have the morphological differentiation of the shoot into stem and leaf, in addition to the separation of a root, and with these there is associated a definite differentiation of tissue and form. All these are often characteristic for whole natural orders or other groupings. In addition to these vegetative features we have the characters of the reproductive organs represented by the essential and accessory organs of the flowers. Natural orders are, as a rule, clearly separated by these. It is true that in the special form of adaptation—whatever the

origin of the latter—many of these common morphological features have become modified, and thus further differences or divergencies may occur. But on the whole, natural orders of flowering plants are characterised and may be separated by the structure of the reproductive organs and by certain definite vegetative features which can be detected even in certain adaptations, which tend to wipe out differences. A very different state of affairs obtains in lichens. Differentiation in the lichen thallus is almost quite free from ancestral morphological tradition which has such a profound influence on the present-day flowering plant. The lichen-fungus has shaken off the habits and the morphological and structural differentiation of its saprophytic or parasitic ancestors and has built up new and mainly physiological traditions. To such an extent has the lichen-fungus broken with its pure fungus traditions that it is no longer generally able to grow as a free fungus on the germination of its ascospore; it is already so dependent on the algae that it cannot grow into a mature plant in their absence. The lichen-fungus again is in such close and intimate touch with the surrounding conditions that its very life depends on an immediate ontogenetic response of the whole lichen-organism to any slight variation in external conditions and the result is a remarkable convergence in type of species not necessarily closely related but growing under similar conditions. Undoubted polyphyletic development has occurred of the whole group of lichens and also of genera and possibly even of species. Some species of Cladonia will doubtless be found to show such development. It was this marked convergence which misled Nylander to construct portions of his system in such a way that the series of the Cladodei included all the fruticulose lichen-genera, and the Parmeliodei and Phyllodei all the foliaceous lichen-genera (12). These series have now been broken up and the genera have been assigned different and more natural places. The classification of to-day—due mainly to Reinke and Zahlbruckner (31)—depends for its main divisions chiefly on the nature of the fungal apothecium and its spores, whereas in natural orders, genera and species pure lichen characters play an increasingly important part. To a limited extent the algae have a determining voice in the separation of certain groups and genera. The limiting of species, already not easy owing to the convergence of types, may possibly be further rendered more difficult by the occurrence of ordinary hybrids. We may get to know more about the possibilities in this direction when we know more about the sexual process which is still only presumed to occur on nevertheless very strong circumstantial evidence. Experimental work may then become possible. Further diffi-

culties might occur owing to the formation of graft hybrids. Tobler describes the building up of a Cetraria thallus by the fusion of numerous small germling Cetraria thalli (29). The same process has been recorded for a crustaceous lichen (1, p. 56). Bitter suggests the possibility of the occurrence of hybrids between *Parmelia tubulosa* (Schaerer) Bitter and *P. physodes* (L.) Ach. although he could not find any actual evidence in favour of this suggestion. He refers to Hue and Nylander, who were inclined to see in certain forms intermediate between *Ramalina fastigiata* and *R. fraxinea* possible hybrids (2, p. 271). A hybrid might be produced in this way conceivably differing "specifically" from either of its parents.

These few remarks indicate some of the difficulties with which the lichen-systematist has to contend when endeavouring to define species.

Incidentally, no one in this country should find any special difficulty in naming British specimens. Miss Lorrain Smith's two big volumes (24) and one small handbook (26) should ensure that. We are to be congratulated on having the lichen literature in this country so up-to-date. Miss Lorrain Smith's textbook on lichens (25) makes our English contemporary lichen literature as complete as can be desired. But these books are only guides —very good ones, it is true—and the chief work has still to be done when the collector brings in his first specimens. Microscopical work is necessary and untold patience and care. Once beyond the initial, difficult and apparently hopeless stage a new world of the greatest interest lies open before the student. Dr Watson's small guide is also a most useful help in the field (30). I wish more of our members could be persuaded to take up the study of lichens.

Lichen ecology is a subject of the greatest interest and importance to the botanist in general and the ecologist in particular. Lichens are so profoundly influenced by their substratum that they immediately reflect its nature and structure probably more than any other group of plants. The lichen growing quite on the outskirts of vegetation initiates the breaking down of rocks and thus aids in the making of soil. The lichen is almost everywhere the pioneer of the whole plant world. It is, with few exceptions, the only plant which is both directly and indirectly independent of an organic substratum and of water stored outside in the substratum or near by. The lichen can therefore grow where practically nothing else will. Arctic and antarctic, alpine and mountainous regions, generally have their rocks covered with lichens as long as they are not permanently covered with snow. Rocks along the sea-coast, and the driest portions of a tree are often covered with lichens. These are found also in the

driest parts of the desert, and are epiphyllous on leaves of trees in the tropical forests.

A very large amount of work has been done since Schwendener's time on the structure of lichens, but it is, on the whole, disconnected and hence our general knowledge of their anatomy has advanced but little. Nobody has worked harder at the structure of lichens than the learned Abbé Hue who died a few years ago. He published two large tomes(13, 14) between 1901 and 1910, and numerous smaller papers containing contributions to our knowledge of the subject. Much of his work consists, however, of rather uninteresting records of minute measurements of cell-sizes, cell-forms, depth of whole thalli and of separate tissues and layers and so on. Little or no regard is paid to the state of development of the lichen as a whole or that of the tissue or the special function of the latter, or to the more important surrounding ecological and physiological conditions which might influence structure. In one such paper(14, no. 589-691) over a hundred crustaceous species of one genus—Aspicilia—are described down to the most minute detail as regards the structure of the thallus. Very little is gained by this, very often not even an easier and surer way of separating two difficult species. As a result of his long experience, however, Hue has proposed a classification of the tissues of lichens, which is to some extent satisfactory, but it is not based on the function of the tissues. Miss Smith gives a full account of this scheme(25, p. 69).

A great deal of anatomical work still remains to be done. It should be realised again that physiological differentiation of the tissues is more marked than traditional morphological differentiation. The lichen is of such great general interest because—as I mentioned before—it has dropped all the traditions, prejudices and memories of its fungal ancestors. No other group of land-plants is as a whole so up-to-date in its structural adaptations. The lichen has no unnecessary vegetative organs or vestiges of such. It must be well adapted, as otherwise under the adverse surrounding conditions it would perish. To appreciate this properly the field lichenologist and the physiologist (and ecologist) must co-operate. There should be no such contrast as existed during the last quarter of the nineteenth century between the followers of Nylander and Schwendener.

In order to discuss some points of general and lichenological interest I will refer to one of our commonest and most highly developed lichen-genera, namely Peltigera, the species of which are foliaceous.

In 1857 Speerschneider(27) described the structure of *P. scutata* Kbr. (which occurs in this country), mentioning the interesting ecological fact that it is calciphobe. *P. scutata* is characterised

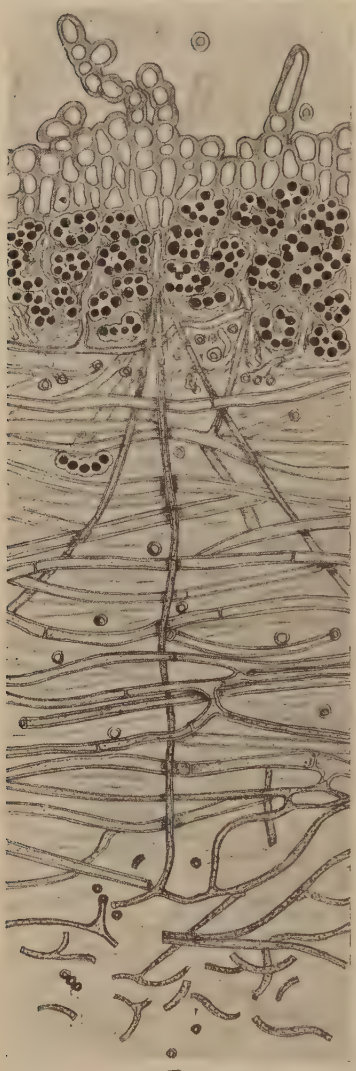

Fig. 1. *Peltigera canina.* Vertical section of thallus at right angles to margin. *a*, cortex; *b*, gonidia; *c*, medulla; *d*, hypothallus. The hypothallus is seen to be connected with the cortex by a fungal hypha. Magn. 225.

by the possession of a sorediate margin. Speerschneider's description is fairly accurate, though he considers that the outer cells of the cortex are dead cells. He records the development of the gonidia from the inside cells of the cortex much in the same way as does Elfving (10). Schwendener, giving an account of the structure of *P. canina* (L.) Hffm. in 1863 (22, III, p. 174), had little to add to Speerschneider's statements. He made some criticisms as regards the condition of the cortical cells and the origin of the gonidia, though he did not put forward his theory as to the dual nature of lichens till 1867. Numerous remarks may be found in literature touching on the structure of Peltigera, but of these many are either incorrect or only misleading. In a paper by M. and Mme Moreau in 1919 (18) an account is given of the structure of the Peltigeraceae. The authors distinguish a cortex, the mycelial elements of the gonidial layer, the medulla and the subterranean mycelium. The latter is figured and I find some difficulty in correlating the figures with anything I have seen in *Peltigera canina*. No portion of the thallus can, strictly speaking, be called subterranean except certain small portions of the rhizines which may penetrate a short distance into the soil, but these soil hyphae show no structural difference from the ordinary hyphae of the rhizines.

In a short paper published after his death by Tobler,

Strato (28) gives, by means of some very diagrammatic drawings, a truer picture of the tissues of *P. canina*. These tissues are upper cortex, gonidial layer, medulla, veins and rhizines. In two very diagrammatic figures he further differentiates correctly the medulla into an inner portion of long straight hyphae, and an outer portion of shorter and much twisted hyphae (28, fig. 1 and fig. 6). The latter are, however, not mentioned in the text. Hue, with his laboriously carried out observations, does not increase our knowledge of the structure of Peltigera to any extent.

The structure of *Peltigera canina* is briefly this (Text-fig. 1). The upper side has a continuous cortex consisting, in the mature parts of the thallus, of hyphae forming rows of fairly large and broad cells. These rows may consist of two to six cells and may be continued beyond the general surface of the cortex in the form of simple or branched hairs which form a kind of felt on the upper side of the lichen. Apart from these hairs the surface of the cortex is rather irregular. The walls of the cells are thick and there are no breathing pores. The cortical cells are living cells, and nuclei and cytoplasm can easily be observed. Though living, however, these cells have lost the power of further division. But they grow in extent considerably, thereby increasing the surface of the whole lichen. The cell-rows of the cortex are directly connected with the felt-like hypothallus of the underside or with hyphae of the medulla.

The gonidia forming a layer just below the cortex belong to the alga *Nostoc punctiforme* (Kütz.) Hariot, and are in groups embedded in a gelatinous sheath. Between these are to be found very fine and short branches of fungal hyphae which do not however get into very close touch with the actual gonidial cells.

The hyphae of the medulla run mainly in a longitudinal direction, that is to say, they radiate towards the margin which they strike roughly at right angles. Immediately below the hyphae of the gonidial layer the medullary hyphae are rather irregular in their course. Most of them, however, run longitudinally but many run at other angles. They are fairly closely packed. Gradually the hyphae are seen to run more regularly. Between the hyphae of the medulla there is much intercellular air-space, though the hyphae are very firmly interwoven, being cemented together by their walls over long distances. Their course is slightly but yet clearly wavy, the medulla thus consisting of a strong system of interconnected strands, the separate units of which in addition frequently anastomose, *i.e.* enter into cytoplasmic connection. The longitudinally running medullary hyphae together form a mechanical system not unlike the system of bast-fibres in the lime and other trees. The hyphae are cylindrical in section and have thick walls. The medulla is very thin

in portions between the veins and very thick where it forms one of the thicker veins. It is from the thicker portions of the medulla that the rhizines arise.

On the lower side of the thallus we find the hypothallus, which consists of loosely packed short-celled and much twisted hyphae, forming a kind of felt. This layer corresponds in every way to the hypothallus of the Pannariaceae and does not here deserve the name of "lower cortex."

The cells of the cortex are seen to be connected by long straight hyphae with the hyphae of the hypothallus. These connecting hyphae date from the actively growing period at the margin of the thallus. The hyphae elongate and the connection remains, the whole forming an important part of the mechanical system of the lichen.

Growth takes place at the margin, where cortex, medulla and hypothallus are soon differentiated. Near the margin the cortical cells measure 0·002 mm. in diameter. In an older portion of the cortex their diameter reaches 0·005 to 0·006 mm. As already mentioned, the surface of the whole lichen considerably increases by this growth in diameter of the cortical cells. The medullary hyphae apparently retain the power of growth for a considerable time, especially the hyphae in the neighbourhood of the gonidia.

The rhizines arise from the lower and thicker portions of the medulla. The inner core consists of hyphae running longitudinally, firmly cemented together and frequently anastomosing, and this core is surrounded by a loose layer continuous with the hypothallus. The apex of each rhizine remains active and spreads out according to the substratum the lichen is growing on. When not in touch with the substratum, or in a dry locality, the rhizines may be short and fluffy. In wetter localities and when in touch with mosses or old Peltigera thalli the rhizines may be longer and almost string-like and in that case their tips only open out into an attachment organ, made up of loose and spreading free hyphae completely covering leaf and stem of the moss without entering any of the living cells.

It is not difficult to make out the functions of the various parts of the thallus. The rhizines mainly absorb water. This they do chiefly at their apices or at points where their internal hyphae are exposed. The loose hyphae of the hypothallus do not absorb water. They will in fact not moisten when water is applied to them. Water is passed rapidly along the veins and then reaches the hyphae in the gonidial layer, and transpiration, at a slow rate, takes place from the cells of the cortex. Our knowledge of the interchange of food between alga and fungus is still very incomplete.

The genus Peltigera possesses three sets of special organs which are made up of both alga and fungus and they are thus organs of interest from the pure lichen point of view. These organs are cephalodia, soredia and isidia. Briefly these organs can be described thus. The *cephalodia* contain gonidia generically different from the normal gonidia of the particular lichen. They always belong to the Cyanophyceae. The *soredia* are small reproductive organs which reproduce the whole lichen. The *isidia* are outgrowths from the lichen thallus, fruticulose or foliaceous in shape, which have some physiological function other than that of reproduction.

First considering cephalodia—these occur invariably in the case of *P. aphthosa* (L.) Willd., being distributed over the upper surface of the thallus. They are small masses of foreign Nostoc-cells caught up and completely surrounded by fungal hyphae of the cortex and are attached by them to the cortical surface. Their function is unknown. It is significant, however, that their gonidia belong to the Cyanophyceae only and that here, as in all other cases, they occur only when the normal gonidia of the lichen are chlorophyceous. Possibly they may be concerned with the fixation of free nitrogen. Bitter (2) has described in the lichen *P. lepidophora* (Nyl.) Wain. the presence of cephalodia containing chlorophyceous gonidia though the ordinary gonidia of this species are also chlorophyceous. Linkola (16) was able to show that, according to their development, these so-called cephalodia are in reality only isidia. The algae of true cephalodia are caught up by the lichen-fungus from the outside; the gonidia of isidia are derived from the ordinary gonidial layer of the lichen. I have been able to follow out the development of Bitter's cephalodia in *P. lepidophora* and I can fully support Linkola in his view that they are isidia only and not cephalodia.

Of much greater interest are the soredia which, with us, occur only on the margin of the thallus of *P. scutata* and in small circular patches on the thallus of *P. canina* var. *erumpens* (Tayl.) Hue. I do not at the moment wish to say whether this is a variety of *P. canina* only or a separate species. In any case the use of the word "variety" seems most inappropriate here. We can either speak of a soredial condition of *P. canina* or of a soredial form. So "erumpens" should be looked upon either as a separate species or merely as a form or condition of *P. canina*. I cannot say that I have really made up my mind as to whether it is a separate species or not. I incline to the former view. The plant is small in size and has very small rhizines. The soredia are small groups of algae surrounded by a few hyphae and these are carried up in a gap of the cortex and gradually separate and ultimately give rise to fresh plants and are thus reproductive

organs which propagate the whole lichen thallus. I have not been able yet to observe how the cortex of this species is broken through for the first time when forming the soralia. I have no doubt from what I have seen so far in this species and in other soralia-bearing lichens that the hyphae of the lichen-fungus are most active in pushing up the algae and breaking through the cortex and thus giving them opportunity to divide and supply fresh gonidia for the formation of more soredia. Gonidial algae will generally divide and increase in numbers if allowed to do so by the lichen-fungus.

I wish to digress at this point for a moment in order to say a few words on the use of the term symbiosis, before continuing my remarks on soredia. The word symbiosis should be used in a very general sense only. Individuals of different species in intimate cellular contact with one another, and intimately dependent on one another, but without either organism being injured or killed by this close contact, may be said to be symbionts. Symbiosis then means a generally harmless but intimate at least cellular association between at least two individuals belonging to different species. Symbiosis is a generic term and if it becomes desirable to define the state of affairs in any one case more accurately a specific definition should be added. This has of course been done over and over again, but generic and specific terms are often used indiscriminately.

Schwendener defined symbiosis as being a state of parasitism of the fungus on the alga. Danilov (7) speaks of a disease caused by the fungus on the alga; Moreau also refers to the condition as one of a disease of the fungus comparable to the galling of Phanerogams by insects (18, p. 125): the fungus is rendered diseased by the intrusion of the alga. Nienburg (19) and others prefer the term helotism, or slavery. Elenkin (9) used the term endosaprophytism, indicating that the fungus ultimately devours the older algae. All these terms indicate antagonism between the two organisms though not to the point of death. Reinke, in using the term *consortium*, wished to define the relationship between the two organisms as that of two partners living peaceably together and working for the common good of the whole complex organism. These terms are specific and may be applicable in certain specific cases. But all cases are examples of symbiosis, which is a generic term. There is no question of the lichen not being an example of symbiosis. However we really do not know enough of the intimate relationship of the two partners to say in every case what specific name should be applied.

There is just one further point to be remembered. I include the physiological condition of all lichens in the term symbiosis.

But this condition has certainly not arisen only once in the transition from free-living fungus and alga to lichen. It is certain that it is of polyphyletic origin. We would for that reason expect some difference in the character of the "species" which form this "genus." The above-mentioned various attempts to define the state of affairs met with in lichens may be justified and be correct, but not necessarily for more than the particular lichen-species examined. It is impossible that they can all be applied to all lichens equally. I am inclined to believe that examples of most could be found among lichens, even to the galling of the fungus by the alga. Moreau, however, generalises, and from using this term to explain the condition met with in Peltigera applies it to that of other lichens. In this he is certainly incorrect.

Evernia prunastri (L.) Ach., a common fruticulose lichen, has been the subject of investigation by various authors. Danilov observed the presence of intracellular fungal hyphae in the gonidia of this lichen. Hence he spoke of the fungus as causing a disease of the algae. Nienburg (19) was able to confirm the facts of fungal penetration in this case. It is this which leads him, together with other observations, to use Warming's term helotism or state of slavery to indicate that the fungus can do with the alga what it likes. Recently Paulson and Hastings (20) examined the same species of Evernia and were quite unable to see any intracellular hyphae, though their observations bear the stamp of very careful and painstaking work. They examined young growing gonidia, thereby demonstrating a very interesting seasonal activity among the gonidia, but on that very account they may have missed the older algae which, according to Nienburg, are those mainly filled with intracellular hyphae. Some work carried out by Miss Ridler in the Cryptogamic Department of the University of Bristol seems, however, to confirm the truth of the observations made by Paulson and Hastings.

The following is to my mind what happens in the lichen. The fungal ascospore germinates and is at first without the algae which it requires as gonidia. Left to itself it would not normally grow up to form a lichen. If finally, however, it gets into touch with its own particular algae which stimulate the fungus to develop into the lichen, the fungus can grow up outside and independently of an organic substratum as the green algae supply the necessary organic food. The fungus, however, supplies water to the algae and, what is more important, it can store water and thus supply the algae with water for a longer period than these would otherwise have at their disposal. There are three things then that the fungus must do in order to allow the algae to grow properly. It must absorb water

efficiently, that is quickly; it must be able to store water and that means that the fungus must reduce transpiration, or, let us say, have it under control. Transpiration must be a noticeably slower process than that of absorption. If this mechanism does not work efficiently the algae will not flourish and will not be able to build up enough organic food and may even die, which would of course also be the end of the lichen-fungus. This threat reduces the activity of the fungus till it can just supply the water necessary for the green algae. So the growth of the algae depends on the efficiency of the fungus and the latter depends on the algae doing their part of the business. The presence of the algae stimulates the fungus to greater activity, but the latter is limited by the influence of the prevailing external conditions. The lichen-fungus cannot outgrow the gonidial layer, and the algae cannot outgrow the lichen-fungus under normal conditions. They work together. The beam of the balance is kept fairly horizontal. This is the normal type of symbiosis which we get in lichens, and it is regulated automatically by co-operation. This form of co-operation is not really more wonderful than the automatic balancing of green plant and colourless toadstool which we find in the forest. At the same time the association in the lichen is far more intimate. It is, however, not entirely and simply the sum total of the activities of a free fungus and free algae. Chemists have shown us that numerous lichen substances, occurring in neither constituent when free, are met with in the compound lichen organism. Tobler has shown experimentally that the hyphae of the lichen-fungus of *Xanthoria parietina* (L.) Ach. do not contain the acid characteristic of the species till they have entered into symbiotic relationship with algae (30, p. 427).

In a discussion on the theory of symbiosis Burgeff (4) in 1909 quotes Elenkin as speaking of a pair of scales, the position of the originally horizontal beam of which indicates the degree of balance as between alga and fungus. The pan, according to Elenkin, holding the fungus is permanently more depressed than that holding the alga, thus indicating the predominance of the former. Resting on his experience with the mycorrhiza in Orchids, Burgeff affirms his belief that symbiosis begins only as soon as parasitism is properly regulated. Not till then would, according to Burgeff, the beam of the balance take up a horizontal position. This form of symbiosis he would then look upon as mutualism.

I do not at all wish to imply that such a term as endo-saprophytism and other similar terms should be dropped. It is quite possible that older gonidia are devoured by the fungus in some cases. Experimental work is necesary to determine the exact nature of the symbiotic relationship in each particular case.

In a paper which is both stimulating and full of interest Church (5) discusses the nature of symbiosis in lichens. He shows to his satisfaction that the lichen-fungus is derived from a marine Floridean ancestor which lost its assimilating layer in a rockpool. This degeneration gave us the fungus and its mycelium of hyphae. Degeneration continued but was at one point arrested by the intrusion of chlorophyll-bearing algae which then became the slaves of the fungus, and thus we get the lichen. Church does not believe that fungus and algae came together and thus synthesised a lichen thallus, at first, of the simplest crustaceous type from which gradually all the highly differentiated forms of to-day have developed. He rather suggests that the crustaceous lichens of to-day are degenerate species developed from bigger fruticulose forms, directly descended from marine Florideans. Personally, I like to look upon *Xanthoria parietina*, a highly developed and well-equipped foliose lichen, as working its way out towards the sea—itself the end of a long line of land-plants, wherever these may have come from originally—and greeting the small phaeophycean *Pelvetia canaliculata*, the descendant of an equally long line of sea-plants; two races of high but different civilisations meeting. Church would, I imagine, look upon *Xanthoria parietina* as the prodigal son returning to his ancestral home—the sea.

I must now refer again to the soredia. These are reproductive organs. Kajanus (15) considers them to be due to the excessive growth of the algae, induced by moist conditions. There is no evidence at all that this is normally the case. The presence of soredia I would associate more generally with dry conditions, as Miss Smith also points out. The bark of trees is often covered with the white soredial masses of *Variolaria* (*Pertusaria*) *amara* Ach. and *V. globulifera* Turn. These places are markedly dry. The soredia are composed of loose tissue and this is as a matter of fact not even easily moistened during rain. The soredia do not become unduly moistened till they have been shed. The wind and small mites, etc., aid in the distribution of the soredia. What then brings about the formation of soredia? They are not simply shapeless gemmae, but are, as Reinke (21) pointed out, emphatically reproductive organs of a compound organism, the lichen. The lichen-fungus—in common with its free ancestors—is imbued with a reproductive impetus, and is ready to reproduce itself at any time should conditions become favourable. This reproductive impetus finds no outlet in many lichen-fungi as far as sexual reproduction of the normal Ascomycete is concerned. The still active reproductive impetus takes the form of a breaking through of the cortex by the fungus carrying with it the algae of the gonidial layer. One can very roughly say that the intensity

of soredial formation varies inversely with the occurrence of apothecia. The fungal hyphae remain automatically in touch with the algae and these increase automatically but slowly when carried up as soredia. In this way the reproductive impetus of the fungus is satisfied and the actual balance of fungus and alga inside the soredium is automatically regulated just as it is in the vegetative thallus.

Turning now to a consideration of isidia. The term isidium was at first applied to the coralline outgrowths on the upper surface of some of the saxicole Pertusarias which were originally comprised in the genus Isidium. The isidia are here minute, fruticulose, terete organs growing on a crustaceous lichen thallus. They occur plentifully also on *Parmelia saxatilis* (L.) Ach., *Umbilicaria pustulata* Hffm., and numerous other species. It is quite evident again that phylogenetic development has followed converging lines. Isidia are also found in the genus Peltigera. There is some difference of opinion as to whether the chief isidia-bearing form is a separate species or a variety of *P. canina* or *P. rufescens* (Sm.) Hffm. It has been given the name *praetextata*. I consider it a condition or state of *P. rufescens*; I am not sure whether there is not also a similar state of *P. canina*. Both Linkola and Wainio consider *Peltigera praetextata* (Flk.) Zopf to be a distinct species (16).

The upper surface of *P. praetextata* often exhibits cracks and the edge of these cracks then gives rise to small leaf-like structures. These are the isidia, which occur also near the margin of the thallus. The hyphae just below and just within the gonidial layer become meristematic and grow out. They form small knobs containing a few algae at first continuous with the ordinary gonidial layer surrounded closely by fungal hyphae. Gradually these small knobs grow up and ultimately form flat leaf-like expansions. These extend more or less in a horizontal plane and are orientated dorsiventrally. They are also, except for their stalks, completely surrounded by a cortex which is continuous with the cortex of the ordinary thallus. But the upper cortex is thicker, with a depth of two or three cells, than the lower which is only one cell deep. The algae are generally fairly evenly distributed between the two cortices. Does not the difference between upper and lower cortex remind one of the difference in structure of upper and lower side of a normal dicotyledonous leaf? The foliose isidia of *P. praetextata* imitate in their dorsiventral structure the leaf of a higher plant. The necessary carbon-dioxide required for assimilation may be supplied through the loose medulla of the main thallus which is continuous with the interior of the leaflets of the isidia. The formation of isidia is brought about by the presence of certain

conditions favourable to an increase in the activity of the lichen-fungus, which make it a more efficient partner in the lichen business. Isidia on Peltigera are found most commonly where conditions are moist. The fungus absorbs more water and the transpiratory surface is increased. The gonidia keep pace with this increase of surface. This is simply automatic co-operation and adjustment. Thus moist conditions in the end permit of an increase in the assimilating surface. Isidia are not reproductive organs, though if separated from their parent plant they have been observed to grow into bigger plants, thus reproducing the plant vegetatively. Kajanus(15) considers that isidia and soredia are both due to excessive activity on the part of the algal gonidia. Tobler, expressing the views of Strato(28), also considers that gonidia are the formative and driving elements in the formation of isidia. I have found that isidia are due to fungal activity in the first instance.

It is very important to realise that the lichen and not the alga alone or the fungus alone gives rise to the isidia. The two organisms work together. Increased activity is due to moist external conditions. It is possible that isidia may in some cases take on an absorptive function. This is, however, not very likely, as water would then probably be given off at the same rate at which it was absorbed, with no advantage to the lichen as a whole.

Generally speaking, there seems to be no doubt that the isidium is an expression of the tendency of the lichen thallus to increase to the utmost its capacity for carbon-assimilation allowing the gonidial layer to expand laterally. Reinke addresses the isidia as assimilators. All lichens seem to have such a goal in view or appear to be moving in that direction. The increase in surface area is controlled by the necessity for the good of the lichen as a whole to keep the beam of the balance horizontal. It is this tendency towards the improvement of assimilatory conditions which has produced foliaceous from crustaceous lichens, and further upright foliaceous, *i.e.* still dorsiventral, and ultimately fruticulose lichens. Some of the simplest crustaceous lichens show this tendency to increase their surface, *e.g. Rhizocarpon geographicum* (L.) DC., a saxicole crustaceous lichen which Miss Holt recently examined very carefully in my laboratory, shows this phenomenon very clearly. The margin of this lichen consists of loose fungal hyphae radiating outwards and very closely applied to the rocky substratum. A differentiation into various tissues cannot at first be made out. Gonidia are present in small numbers only and have clearly been picked up by the marginal fungal hyphae. As the margin advances these algae grow and divide. The growing algae stimulate the fungal hyphae to increased activity, and fungus and algae

gradually grow upwards away from the substratum. Small basalt-like pillars are formed which rest on the thin hypothallus which is directly applied to the substratum. Between the pillars are narrow gaps, giving the lichen thallus the characteristic chinked or areolate appearance always found in the typical saxicole crustaceous lichen. The immature undifferentiated, but most actively growing, part of the thallus I call the protothallus, the mature areolate portion the metathallus. The pillars of the metathallus are—as is well known—a wonderful arrangement for keeping the algae well supplied with water. The whole surface of the pillars, *i.e.* upper surface, and the sides especially, not being covered by the old scaly primary cortical cells like the upper surface, absorb water actively. A drop of water falling on to the lichen is drawn into the narrow cracks or chinks by capillary attraction and is then rapidly absorbed by the sides of the pillars. The inner tissues of these pillars now swell up and the cracks close up. The water has been absorbed by a big surface, but for transpiration with the cracks closed at first there is only available the upper surface of the pillars. This is also covered with a thick layer of the dead cells of the primary cortex. Transpiration is thus much slower than absorption and so water is stored and fungus and algae flourish. Certain portions of the protothallus do not succeed in picking up algae. They do not grow up but will in the end form apothecia and spermogonia. But I would not like to say which is cause and which effect.

We have here then the same simple symbiotic relationship between alga and fungus regulated automatically which we had in Peltigera. We see also the same tendency of the lichen to increase the assimilating and water-absorbing surface as much as external conditions will allow.

A short time ago I received from Mr F. J. Chittenden a few lichens from China. One of these was a big specimen of *Cladonia squamosa* (Scop.) Hffm. var. *muricella* (Del.) Wainio. This specimen exhibits most completely the height to which physiological differentiation can go in the lichen. The flat protothallus is gone but there remains the upright podetium of the metathallus perfectly differentiated into stem and leaf. The leaf or assimilator shows a very marked dorsiventral orientation. The loose-tissued lower side is well adapted for the admission of carbon-dioxide. These leaves show how near their goal the Cladonias have come. Permanently adverse conditions prevent the crustaceous *Rhizocarpon geographicum* realising this ambition beyond forming the pillars just described. Peltigera can only show now and again what is "in its mind" by developing isidia.

I hope I have succeeded in showing the lines along which the evolution of the lichen is proceeding. The fungus develops its

vegetative organs almost entirely inside its organic substratum away from the light. These organs are apheliotropic. The algae develop in the light. Associated with these green organisms the lichen-fungus has become positively heliotropic and has forsaken its organic substratum.

It is also, I hope, clear from what I have said that systematist and physiologist must co-operate in the study of the lichen, just as alga and fungus co-operate in the lichen itself.

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STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate I and 3 Text-figs.)

IV. SOME CEYLON CORDYCEPS.

By T. Petch, B.A., B.Sc.

In the *Fungi of Ceylon*, Berkeley and Broome enumerated five species of *Cordyceps*, two of which were new, viz. *C. Barnesii* and *C. dipterigena*. As was pointed out by Massee, one of the five records was based on a misidentification; the specimen attributed to *C. sobolifera* being *C. Barnesii*. Massee added two other species to the Ceylon list, but in both cases the identification appears to be incorrect. During recent years, further species have been collected, bringing the total known *Cordyceps* of Ceylon to ten. In addition, several species of *Isaria* are known, of which the perfect stage has not yet been observed.

The localities in Ceylon from which species of *Cordyceps* have been recorded are, at least as far as relates to the species found on the ground or in rotting wood, chiefly in the higher districts. It is possible that an observer stationed in the low-country might be more fortunate in obtaining these fungi there than I have been, but even at Peradeniya (1600 ft.) they have been very rare during the last eighteen years. I have only one record from Peradeniya, viz. a single specimen of *C. Barnesii*. This distribution coincides with that of the subterranean fungi, *Hydnangium*, *Rhizopogon*, and *Hymenogaster*; and one is inclined to associate it with the absence of those keen mycophagists, the termites, from the higher regions of the hill country.

Cordyceps dipterigena, *C. unilateralis*, *C. Blattae*, and "*Isaria crinita*," are invariably found attached to living leaves or stems. The first two of these have been collected in the low-country, and *I. crinita* at a medium elevation. When the first three of these occur on living leaves they are always attached to the under surface, and a similar condition prevails in the case of spiders attacked by *Torrubiella flava*, *Gibellula elegans*, etc., the

insect being fastened to the leaf by strands or pads of hyphae round its feet, or by a weft of hyphae from its body. It would appear to follow that the hyphae of the fungus grow out from the insect and fasten it to the leaf before it dies; otherwise the insect would fall off when it died. Consequently, it would appear that the occurrence of the insects in the position described is evidence against the theory that these fungi grow on their several hosts only after the death of the latter.

Cordyceps dipterigena, *C. unilateralis*, *C. myrmecophila*, and *Isaria crinita*, contrary to the more general rule in *Cordyceps*, develop from the perfect insect. *C. Blattae* might be included with these, as, although the cockroach bears fertile clavae in the nymphal stage, it is nevertheless an active stage.

C. unilateralis has been found in Ceylon on one occasion only, and then not by a mycologist; yet three specimens were obtained, one on each of three leaves. As, however, ants are gregarious, it might be expected that several would be infected at the same time. *C. dipterigena* has been collected on several occasions, and it is usually possible, when one has been found, to obtain several others, up to twenty, by a careful examination of neighbouring bushes. The latter fact suggests that the insects are infected when they are in close association, *i.e.* in the larval stage, and that the clavae do not develop until the insect is mature.

CORDYCEPS.

A. Perithecia immersed in the Stroma.

Cordyceps Barnesii Thwaites. This species (Plate I, fig. 1) was described by Berkeley and Broome in *Fungi of Ceylon*, No. 977, the name being suggested by Thwaites in honour of Mr R. Barnes, who first called his attention to it. The fungus occurs on cockchafer grubs, and it was apparently common in the days of coffee in Ceylon, when "grub" was one of the coffee-planters' enemies. There is an abundance of Ceylon material in Herb. Kew and specimens in Herb. British Museum and Herb. Peradeniya, all collected by Thwaites, while Beccari collected it in the Botanic Gardens, Peradeniya, when he passed through Ceylon on his way to Borneo. At the present day, however, it appears to be rare, and I have obtained only one recent specimen.

Berkeley and Broome's description is "Stipite cylindrico velutino: clavula cylindrica, apice sterili; conidiiophoris ramosis stilboideis candidis, capitulis globosis (no. 1120, cum icone). On larvae of *Melolontha*. Conidia ·0001 [inch] long."

The fungus (clava) attains a height of 6 cms., but it is not conspicuous. The stalk is fuscous or blackish brown, rather paler towards the base, the ascigerous part sordid reddish

brown, and the sterile tip pale yellow or whitish. The fungus consequently has a somewhat dingy appearance.

The stalk is cylindric, up to 2 mm. diameter and 4·5 cm. high, glabrous. The "minutely velvety" of the original description, and the strigose appearance depicted by Massee, relate only to that part of the stalk which is embedded in the soil and is consequently somewhat tomentose or clothed with fibrils. The head, or perithecial region, is sharply differentiated from the stalk, being abruptly thicker, 3–5 mm. diameter; it is 8–15 mm. long, with the upper and lower edges rounded and usually oblique, or incised on one side, not symmetrical. Above the perithecial region there is usually a sterile conical apex, up to 5 mm. long.

When fresh, the perithecia are completely immersed and the head is smooth, but in dried specimens the ostiola project slightly and the head is rough. The perithecia are conoid, 0·35 mm. deep, 0·15 mm. diameter, with a yellowish-brown wall. The asci are cylindric, capitate, very shortly pedicellate, eight-spored, 160–220 × 8–10 μ. The spores are linear, as long as the ascus, in a parallel bundle, and divide into part-spores which are very variable in length. In some asci the part-spores are 30–40 × 2 μ; in others, they are only 9–12 × 2 μ. This variation occurs both in Thwaites's specimens and in that recently collected. It appears to be not an uncommon phenomenon in the case of linear ascospores which divide into part-spores when mature.

The conidial stage of this species differs completely from that usually associated with *Cordyceps*. It was briefly described by Berkeley and Broome, and was figured by Massee, but that such a conidial stage can belong to a *Cordyceps* has been generally overlooked. The immature clavae bear scattered, white, stilboid conidiophores. These may be simple, up to 1 mm. high, or repeatedly branched at a wide angle, up to 4 mm. high, the branches terminating in ovoid, compact heads, 0·1–0·2 mm. diameter. The stalk of the stilboid conidiophore is composed of parallel hyphae; and these separate at the apex, or at the apices of the branches, to produce a normal *Stilbum* head of conidia. The conidia are hyaline, globose, 0·75 μ diameter, or oval, 1·5–2 × 0·75–1 μ, adherent in a solid mass. When the head is bearing perithecia, these stilboid conidiophores may still be present on the conical tip. A similar conidial stage occurs in *Cordyceps falcata* (Plate I, fig. 12).

In *Fungi of Ceylon*, No. 978, Berkeley and Broome recorded for Ceylon, *C. sobolifera* Berk., "on larvae of some lamellicorn insect at the roots of coffee-trees. Bolagodde." As previously noted by Massee, the specimens are *C. Barnesii*.

Cordyceps gracilis (Grev.) Dur. and Mont. A single specimen (Plate I, fig. 2), which appears to be referable to this species,

was collected at Hakgala. Unfortunately it was dug up somewhat carelessly and detached from its host, and further search for the latter was unsuccessful.

The available part of the stalk is cylindric, 5 cm. high, 2–2·5 mm. diameter. The head is subglobose, 4 mm. diameter, sharply differentiated from the stalk, smooth, the ostiola not projecting. The perithecia are totally immersed, crowded, flask-shaped with a rather long neck, 0·3 mm. diameter, 0·4–0·6 mm. long, the length increasing towards the apex of the head. The asci are 6 μ diameter, of the usual type, and the part-spores are cylindric, 4–8 × 2 μ.

In general appearance this agrees with *C. gracilis*, but its colour when fresh was white, with a faint pinkish tinge on the head. The ostiola were not visible, and it was thought that the specimen was immature. The dry specimen is brown to yellow-brown, the head punctate with darker ostiola.

C. podocreoides von Höhn., from Java, is somewhat similar, but has stalks expanding upwards, and heads rough with projecting ostiola. Its perithecia are oval, 0·4 × 0·3 mm., and its part-spores, 8 × 1 μ. Von Höhnel described the colour as "from ochre yellow becoming brown," but it has to be borne in mind that, although he collected in Java, his specimens of *Cordyceps* were chiefly old specimens previously collected by other workers.

Möller, who gathered *C. gracilis* in Brazil, stated that it was loam-brown, with a slight reddish tinge on the head of one specimen.

C. gracilis is usually described as brown. Whether it is white at any stage has not been recorded, as far as the available literature indicates. Another possible difference from the Ceylon specimen is the size of the part-spores. The Tulasnes described the part-spores of *C. gracilis* (*entomorrhiza*) as 6·5–8 × 4 μ, a much broader spore than in the Ceylon species. However, they figured the part-spores of an Algerian specimen, and the dimensions of those in the figure are quite evidently not as stated by them.

Cordyceps coccinea Penz. and Sacc. This species, which was originally described from Java, has been found at Hakgala, Ceylon, on a coleopterous larva in decaying wood. Several clavae arise from the one larva.

The clava (Plate I, fig. 3) is up to 13 mm. high, with an orange-red head, and a stalk of the same colour, becoming paler below. The stalk is terete, glabrous, 0·3–0·4 mm. diameter, becoming horny-looking and dark red-brown when dry. The head is ovoid-cylindric, 3–4 mm. high, 1·25–1·75 mm. diameter, rough with rounded protuberances, up to 0·15 mm. high, in which the ostiola are situated. In section, by transmitted light, the peri-

pheral layer is yellow-brown. The perithecia are immersed, crowded, elongated flask-shaped, 0·35 mm. high, 0·1 mm. diameter. The asci and spores are of the typical *Cordyceps* character, the part-spores being cylindric, 2–4 × 1 μ.

This differs from *C. militaris* in its immersed perithecia. The perithecia in the Ceylon specimens are more crowded than in Penzig and Saccardo's figure.

Cordyceps dipterigena B. and Br. This species was described by Berkeley and Broome in *Fungi of Ceylon*, No. 980, as "Pallida, stipite cylindrico; capite globoso; ostiolis inconspicuis. Sept. 1864. About 1½ inch high." The latter figure is probably a misprint for half an inch. Cooke, *Vegetable Wasps and Plant Worms*, p. 226 (1892), refers to this species, but he does not appear to have seen a specimen, as he quotes the height as an inch and a half without comment.

Massee (in *Ann. Bot.* IX, p. 20) gave a fuller description as follows: "Gregarious; stems simple, ½–1 cm. high, 1 mm. thick, cylindrical, smooth and even, pallid, head globose, smooth, pallid, about 3 mm. across; asci cylindrical, narrowed below into a long, slender pedicel, apex capitate, 8-spored; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, multiseptate, slightly constricted at the septa, and apparently always breaking up into the component cells, which are linear-elliptic, ends narrowed, truncate, hyaline, 10 × 1·5 μ, before leaving the ascus. On dipterous insect. Ceylon (Thwaites). Type specimen in Herb. Kew., examined." Massee figured two clavae arising from an adult fly, but as far as can be determined, they are shown as growing from the under surface of the insect, which is the reverse of the usual position.

This species has been found on several occasions in the jungle at Hakgala (5600 ft.), always on flies of the genus *Mydaea*. The dead insects are situated on the under side of living leaves, or on small twigs, to which they are attached by a fimbriate, rather coarse, rufous brown border of mycelium. It has also been found at Ratnapura, in the low-country, on a fly of the same genus; and one of Thwaites's specimens is also from the low-country (Pasdun Korle).

Typically, the dead fly bears two perithecial clavae (Plate I, fig. 4), symmetrically situated, one on either side of the thorax, and a conidial clava from the tip of the abdomen. The conidial clava, however, is often absent. I have gathered a specimen with three immature perithecial clavae arising from the thorax, but have not met with one having any greater number. As a rule the clavae are simple, but the specimen from Ratnapura bears two immature perithecial clavae, one of which has two short lateral branches.

The perithecial clavae are up to 6 mm. high, and consist of a well-defined stalk, about 0·3 mm. diameter, and a flattened-globose head, up to 2·5 mm. diameter. The stalk may be so short that the head appears to be sessile, and, in general, the long-stalked examples have the smaller heads. Immature examples are pallid or greyish white, but when mature the stalk is dark brown to black, longitudinally fibrillose, usually expanding upwards, while the head is yellow-brown to red-brown, glabrous, with darker, subtranslucent, scattered ostiola which may or may not project. The head is sharply differentiated from the stalk, and may have a flat base, or is sometimes umbilicate below.

The conidial clava is usually longer, up to 2 cm. long, and 0·25 mm. diameter, almost equal. At first it is brown with a white bloom, but becomes dark brown to black, grey at the apex, usually irregularly bent in the upper part. Conidia are present in the early stage, before the clava has become dark brown; they are clavate, or almost cylindric, 6–9 × 1·5–2 μ, and are borne on cylindric, verrucose basidia, 16 × 2 μ, which form a continuous external palisade layer.

In the larger specimens the head is generally flattened-globose, even, with the margin uniformly rounded above and below; but examples occur which are verrucose with strongly projecting ostiola, and others in which the vertical edge is grooved or fluted. The specimens with smaller heads show more variation. In several examples the head is barrel-shaped, *i.e.* taller than usual relatively to the breadth, with a convex, vertical side and a flat top; or it may be of the same general shape, but contracted upwards so that the top is smaller than the base (Plate I, fig. 5). In these latter forms, the ostiola are confined to the flat top, and the fungus is then *C. Ouwensii* von Höhnel, which is certainly identical with *C. dipterigena*. In one extreme variation the head consists of a digitate group of six, almost distinct, perithecia (Plate I, fig. 6).

The perithecia are immersed, vertical, crowded, elongated oval or obtusely flask-shaped, up to 0·8 mm. high, 0·25 mm. diameter, occupying almost the whole of the head, except for a small white region at the base. The wall of the perithecium is thin and hyaline. The asci are cylindric, capitate, 250–500 μ long, 5 μ diameter, and contain eight filiform spores, almost as long as the ascus, in a parallel bundle. The part-spores are narrow-oval, ends obtuse, 4–6 × 1–1·5 μ. Massee's measurement of the part-spores appears to be too large, while his figure of the perithecia has no resemblance to reality.

In Herb. Kew, *sub Cordyceps dipterigena*, there is a specimen from Ceylon—a fly which bears nine immature perithecial

clavae. This was marked by Massee, "not *dipterigena*," and it is apparently the Ceylon specimen referred by him to *C. albella* (B. and C.). It was named *C. Thwaitesii* by Lloyd, but, as Thaxter has pointed out, it is *C. dipterigena*, though it differs from all other Ceylon specimens in having such a large number of perithecial clavae. Like the recent Ceylon specimens, it is on a species of *Mydaea*.

Massee (*loc. cit.* p. 23) also recorded for Ceylon, *C. armeniaca*, on a coleopterous insect. The Ceylon specimen in Herb. Kew appears to be *C. dipterigena* on the remains of a fly.

In *Trans. Brit. Myc. Soc.* VII, p. 28 (1921), I suggested that *C. coccigena* (Tul.) Sacc. really grew on a fly and was identical with *C. dipterigena*. I have since found that the similarity of the two species was noted by von Höhnel.

Specimens of *C. dipterigena* are frequently parasitised, either by another Hypocreaceous fungus, *Byssostilbe tomentosa* Petch, or by a Hyphomycete, *Sporotrichum album* Petch.

C. muscicola Möller would appear to be identical with *C. dipterigena*. Möller's figure shows six clavae arising from one fly.

Cordyceps myrmecophila Ces. This species was recorded for Ceylon by Berkeley and Broome in *Fungi of Ceylon*, No. 979, from Thwaites 1218, *cum icone*. They gave a description of the species, as follows: "*C. myrmecophila* Ces. (*sub* Hypocrea); Rab. (no. 1033). Ochroleuca: stipite filiformi tenacello; clavula ovoidea ad basin sterili, superne costata acutiuscula, e peritheciorum summo ostiolo, gibberulosa. On dead ants."

There is no Thwaites's specimen in Herb. Peradeniya, and none has been collected recently. The figure (Plate I, fig. 7) shows a specimen, 3 cm. high, with a flexuose stalk, 0·2 mm. diameter, and an ovoid, somewhat pointed, head, 3·5 mm. high, 1·5 mm. diameter. The whole fungus is pale yellow. The coloured drawing shows the head smooth, but a separate pencil drawing, unfortunately not enlarged, shows longitudinal ribs and projecting ostiola.

The description given by Berkeley and Broome does not coincide with that in Saccardo, *Syll.* II, p. 586, but is the same as that quoted by them in *Ann. Mag. Nat. Hist.* Ser. 2, VII, p. 186 (1851), when recording the occurrence of *C. myrmecophila* on an Ichneumon, at Leigh Wood, Somerset. It was not drawn up from the Ceylon specimen, as might be imagined from its inclusion in the *Fungi of Ceylon* without quotation marks.

In shape, the Ceylon drawing is similar to the figure of *C. australis* Speg., given by Möller, and that of *C. depokensis* Koord.

Cordyceps unilateralis (Tul.) Sacc. var. **javanica** von Höhn. Three examples of this species were collected together at Anur-

adhapura, in the low-country, on ants attached to living leaves. A single clava arises in each case from the head of the insect. The insect is sparsely covered with brown mycelium which fastens it to the leaf chiefly at the feet (Plate I, fig. 9).

The clava is up to 12 mm. high, thin and flexuose, 0·4 mm. diameter below, tapering upwards, black or black-brown and minutely tomentose or bristly below, ashy in the upper half. The perithecial discs or plates are laterally attached, and situated on the lower half of the clava. One specimen has a single perithecial plate, another has two, while the third has four, three on one side and one on the other, situated 2·5–4 mm. from the base. The discs are black, glabrous, circular, 0·9 mm. diameter, 0·4 mm. thick, with a sharp upper edge, contracted below and sloping inwards to the point of attachment: in some cases they are slightly curved round the clava. The upper surface is slightly convex, tuberculate with close-set tubercles, 0·05–0·1 mm. diameter. Internally the discs are white. The perithecia are conical or flask-shaped, 0·2 mm. deep, 0·1 mm. diameter, with a yellow-brown wall. Unfortunately the available examples are immature.

The outer layer of the disc is parenchymatous, and by transmitted light the "cell walls" appear as a coarse irregular network, with meshes 8–20 μ broad, divided by thinner lines into smaller meshes.

The upper part of the clava bears conidia. These are hyaline, oval, 3–5 × 1 μ, borne on basidia having a total height of 24 μ and consisting of an oval base, 8 × 4 μ, bearing a slender, almost equal, sterigma, 1 μ diameter and up to 16 μ long. The conidial stage of this *Cordyceps* is consequently *Hirsutella*.

The Ceylon specimens agree with von Höhnel's figure and description, except that his specimen had much more pronounced tubercles or perithecial elevations. *Isaria myrmicidae*, in Lloyd, *Mycol. Notes*, No. 62, p. 915 (1920), would appear to be the conidial stage of this species.

Cordyceps Blattae Petch, n. sp. This species has been collected at Hakgala on two occasions, on a cockroach (*Blatta germanica*) attached to the underside of living leaves. A slight covering of brown mycelium overruns the insect and fastens it to the leaf.

The clava (Plate I, fig. 8) is cylindric, 1 cm. high, with a very short sterile base, 0·5 mm. diameter, from which it expands upwards regularly to a diameter of 1 mm. at the rounded apex. It is grey or lavender, the tissue being dark red-brown, covered with a grey or lavender pruina. The substance of the club is rather soft and viscid, and shrinks as it dries, so that the originally even, unicolorous clava becomes covered with minute,

red-brown, longitudinal protuberances arranged in vertical lines. In section, by transmitted light, the outer layer of the clava is purple-red.

The perithecia are immersed, conoid, 0·2 mm. high, 0·15 mm. diameter, with ostiola scarcely projecting. The asci are 100–130 × 8–12 μ, cylindrico-clavate, or narrow clavate, with or without a tapering pedicel, four- or eight-spored, the apex of the ascus being slightly thickened, but not capitate. Paraphyses are absent.

The ascospores (Plate I, fig. 14) are in a parallel bundle, spirally twisted, but the individual spores do not extend from the base to the apex of the ascus. As a rule, two reach the apex of the ascus and one extends downwards towards the base. They are elongated fusoid, 50–80 × 3–4 μ, usually acute, hyaline, multiseptate, with strong septa 5–8 μ apart.

It will be evident that the ascus and ascospores are quite different from the typical form in *Cordyceps*. The ascus is clavate with a slightly thickened apex, instead of cylindric with a capitate apex, and the spores, instead of the usual parallel bundle of linear spores, terminating at the same level, end at different levels and are elongated-fusoid. From the shape of the spores, it would seem improbable that they divide into part-spores. The spores and asci are those of an *Ophionectria*, not those of a *Cordyceps*, and the fungus may be regarded as an *Ophionectria* having perithecia embedded in a vertically-elongated stroma.

There would appear to be some probability that *Cordyceps unilateralis* may have similar asci and spores. Von Höhnel's illustration shows spores with well-developed septa, and a spore-bundle terminated by the tip of a single spore, but unfortunately only the end of the spore-bundle is figured. The figure was not drawn by von Höhnel. From von Höhnel's description, however, it would seem that all the spores were almost as long as the ascus. Another species described by von Höhnel, *C. rhizoidea*, has eight spores, each about half the length of the ascus, in an irregular bundle, and thus resembles *C. Blattae* in that respect, but the spores are different in shape and continuous.

B. Perithecia superficial.

Cordyceps falcata Berk. A species which appears to agree with *C. falcata* Berk. has been collected on several occasions at Hakgala on a coleopterous larva in rotting logs. The Ceylon specimens are smaller than those in the type from India.

The clavae (Plate I, figs. 10, 11) emerge through the holes made by the larvae. The perithecial clava is up to 2 cm. long, 1–1·5 mm. diameter at the base, cylindric or compressed, usually curved, tapering upwards to an acute apex, minutely tomentose,

white, becoming pinkish or reddish. The perithecia are superficial, usually developing in a continuous group, two or three millimetres above the surface of the wood, on the convex side of the clava or encircling it, but in the latter case they are more numerous on the convex side than on the other. In some instances scattered perithecia occur, apart from the main group. Massee's statement that the barren areas on the clava in the type are due to the fact that the perithecia have fallen off is incorrect, if the Ceylon and Indian species are identical. Barren clavae, *i.e.* clavae which have not yet developed any perithecia, are generally common. The clavae which are producing perithecia have a sterile tip, 2–10 mm. long.

The perithecia have a pinkish tinge when fresh, but become reddish brown when dry. They are ovate, up to 0·6 mm. high, 0·4 mm. diameter, with the apex somewhat narrowed and produced, and are slightly tomentose. They may be loosely adherent to one another laterally, but are not immersed in the stroma. The asci are cylindric, 340–440 × 8–10 μ, and the ascospores divide into part-spores within the ascus. In one collection, the part-spores are 4–8 × 1·5 μ, in another 8–12 × 2·5 μ, cylindric with rounded ends. In the latter, the part-spores were extruded from the perithecium in a yellowish drop.

The conidial stage (Plate I, fig. 12) similarly emerges from the beetle-boring as a tuft of short, branching, much-divided conidiophores. As a rule, these are rigid and short, but in some instances they are lax and up to 2 cm. long. The conidiophore, in general, originates on the larva as a single stalk, and branches when it reaches the exterior of the wood, but in the longer lax forms, branching only occurs at some distance above the surface. These latter forms are generally found on the lower surface of the log, and the difference is no doubt due to greater humidity in that situation. The conidiophore divides at a wide angle, and each branch terminates in a minute, white or yellowish, globose or ovoid, solid, glabrous head. The conidia are hyaline, oval or subglobose, 1·5–3 × 0·75–2 μ. The type of conidiophore is thus stilboid, and in this respect *C. falcata* agrees with *C. Barnesii*. If the perithecial clava is kept in a damp chamber, it develops the stilboid conidial form from the sterile apex. *Stilbum ramosum* Peck, found on similar larvae, would appear to be a parallel species.

According to my notes, there are specimens of this species, collected by Thwaites, included under *C. militaris*, in Thwaites 341 in Herb. Kew.

Cordyceps translucens Petch, n. sp. This species was found at Hakgala, among dead leaves, on a larva of a coleopteron. Several clavae arise from the one larva.

When fresh the clava (Plate I, fig. 15) is hyaline and translucent, with the central portion of the stalk and the contents of the perithecia appearing white and opaque. When dry it becomes amber-coloured or yellow-brown, and horny. The total height is up to 1 cm. The stalk is stout, erect, or curving upwards, 1 mm. diameter. The head is well differentiated from the stalk, globose or ovoid, up to 2·5 mm. high, 2 mm. diameter, bristling with strongly-projecting perithecia. The perithecia are superficial, broadly conoid or flask-shaped, 0·5 mm. high, 0·3 mm. diameter, with a cylindrical ostiolum, 0·05 mm. high and broad. A few isolated perithecia may occur on the stalk. The perithecia are united laterally by a slight weft of mycelium, the upper half being free and glabrous. The asci are cylindric, capitate, 4 μ diameter, with eight spores of the normal type, and the part-spores are cylindric, 6 × 1 μ.

Cordyceps pruinosa Petch, n. sp. This species was collected by Thwaites at Nuwara Eliya (No. 341 in part) and was assigned by Berkeley and Broome to *C. militaris*. There are specimens of that gathering in Herb. Kew and Herb. Peradeniya. I have a recent specimen, on a cocoon, but the clavae are immature. The type was said to be on pupae.

According to Thwaites, the clavae (Plate I, fig. 13) were bright crimson when fresh. The specimens in the Peradeniya Herbarium vary in height from 1·5 to 4·75 cm. The stalk is about 0·5 mm. diameter, and the head narrow-clavate or subcylindric, acute above, 7 mm. high, 1·5 mm. diameter. The stalks of the herbarium specimens still bear a red pruina, and the same red pruina occurs between the apices of the perithecia. The red colour changes to violet with caustic potash.

The perithecia are narrow-oval or ovoid-cylindric, 0·4 mm. high, 0·1 mm. diameter, with a conical apex, superficial, closely crowded together. The wall of the perithecium, by transmitted light, is pale yellow, with a vivid crimson apex. The asci are 4–6 μ diameter, of the normal type, eight-spored, and the part-spores, cylindric, 6 × 1 μ.

In the recent example, the cocoon bears about ten immature clavae. These are crimson, narrow-clavate or almost linear, up to 1 cm. long and 0·1–0·4 mm. diameter, strongly longitudinally fibrillose. On one of these the perithecia are just developing.

This species would appear to differ from *C. militaris* in the fibrillose immature clava, and the red pruina when mature.

ISARIA.

The conidial stages of the various species of *Cordyceps* are not in all cases co-generic with *Isaria farinosa* (Dicks.) Fr., the conidial stage of *Cordyceps militaris*. As already stated, the

conidial stages of *C. Barnesii* and *C. falcata* are compound Stilbums, occurring in the former on the immature perithecial clava, and in the latter independent of the perithecial clava. Further, the conidial stage of *C. unilateralis* is a *Hirsutella*, while that of *C. dipterigena* does not appear to fall into any genus yet described. It is consequently to be expected that an examination of the "Isaria" stages of the various species of *Cordyceps* would show that they belong to a wide range of genera of the *Hyphomycetae*. The examination should, of course, aim at determining the character of the ultimate branches of the conidial stroma and the mode of attachment of the conidia.

The following notes have been made on several species of *Isaria* which occur in Ceylon on insects, but of which the perithecial form has not yet been discovered.

Isaria Sinclairii (Berk.). This, the largest *Isaria* yet found in Ceylon, occurs fairly frequently at Hakgala on *Cicada* pupae, usually growing in clusters from the insect (Text-fig. 1). It is up to 6 cm. high, with a white stalk up to 2·5 mm. diameter below, branching above, the branches bearing ovoid, irregular, loose heads up to 1 cm. high and 5 mm. diameter. The conidia are oblong-oval, ends sometimes acute, hyaline, continuous, 8–10 × 2–3 μ, on basidia which are borne in clusters, either surrounding the conidiophore or terminal. The basidia are broadly flask-shaped, about 6 μ high, and 3 μ diameter below, the basal part being subglobose. It belongs to the section *Verticillium* of Vuillemin, and it does not appear to differ from *Isaria arbuscula* Hariot from Mexico, and *I. Hariotii* Arnaud from Madagascar, both of which have the same type of conidiophore, and conidia, 7–10 × 2–3 μ, and 5·5–7 × 2·5–3 μ, respectively.

Fig. 1. *Isaria Sinclairii*, on a cicada pupa, × $\frac{3}{4}$.

Von Höhnel described *I. amorpha* on a cicada in Java, but that species is said to have spores only 3–4 × 1–1·5 μ. The *Isaria* form known as *Cordyceps Miquelii* (Tul.) Sacc., on *Cicada* pupae in Brazil, has cylindrical conidia (*fide* Cooke), but is

insufficiently described. *C. sobolifera* Tul., on *Cicada* pupae in the West Indies, appears to be different, as far as can be determined from the published descriptions. The Ceylon species appears to be identical with *C. Sinclairii*, on *Cicada* pupae in New Zealand, the conidia of which are said to be oblong, and 7 μ long; but it would seem probable that all the species of *Isaria* with large conidia which have been recorded on cicadas are the same.

Isaria sp. on Lepidoptera. This species occurs at Hakgala on pupae of *Agrotis*, etc. It is up to 4 cm. high, with a lemon-yellow stalk and a white, divided head. The stalk becomes dull brown when dry, but still shows the yellow colour when mounted; it is about 0·5 mm. diameter, longitudinally fibrillose, branching above, the branches being suberect and each terminating in an ovoid head of contiguous branchlets. The yellow branchlets give off hyphae, 2 μ diameter, on which flask-shaped basidia, 6 × 2·5 μ, are borne in clusters, either surrounding the hypha, or terminally. The *Isaria* heads are thus composed of spheres of basidia and conidia, about 40 μ diameter. The conidia are oblong-oval, or oval and inequilateral, or cylindric, sometimes curved, 3–4 × 1–2 μ. The type of conidiophore at first sight appears to be that of *Beauveria*, but the characteristic sterigmata of the latter genus are absent, the spores being apical on the basidium and (as observed) solitary or in a short chain of three or four. In the larger specimens, the main stalk may be clothed with these spheres for half its length.

This species would appear to resemble *Isaria tenuipes* Peck. Pettit stated that the latter species had basidia in whorls or opposite, after the type of *Verticillium*, but he gave the spores as oval to globose, 2·5–3·5 μ, in a spherical cluster or sometimes an irregular chain at the apex of the basidium. The Ceylon specimens would be assigned to *Spicaria*, from the fact that the conidia may be in chains; but it may be considered doubtful whether it will be practicable to maintain as distinct groups *Verticillium* forms and *Spicaria* forms of *Isaria* on that character.

Isaria sp. on Lepidoptera. This species has been taken on a caterpillar and on cocoons at Hakgala. It is white, up to 7 mm. high, with a slender stalk, 0·15 mm. diameter, branching profusely but with branches often widely separated from one another, each branch terminating in a loose head of plumose branchlets. The branchlets are covered with stalked conidiophores, up to 50 μ high, each bearing a sphere up to 40 μ diameter. These spheres are clusters of basidia, as in the foregoing species, from which this differs in having the majority of the spheres terminal on short, rigid conidiophores perpendicular to the branchlet. The conidia are oval or subcylindric, curved in one aspect,

4 × 1 μ. In the arrangement of the conidiophores this species resembles *Verticillium Barbozae* Vincens, as figured in *Bull. Soc. Myc. France*, XXXI, plate IV. Vincens stated that he had not been able to find more than one spore at the apex of a basidium, and that nothing in the appearance of the spores favoured the supposition that they were formed in chains; hence the fungus was not a *Spicaria*. In the Ceylon species, however, the conidia may occur in short chains.

Isaria sp. on Lepidoptera. I have this form on a larva in rotting wood from Hakgala, and on a Tineid case from Peradeniya. In the latter the clubs arise round the mouth of the case. The clavae are scattered, simple, up to 5 mm. high. The stalk is slightly yellowish, about 0·2 mm. diameter at the base, tapering upwards to about half the height of the fungus, where it passes into the head and is continued to the apex as an unbranched columella. The head is narrow-clavate, or narrow-cylindric, 2·5 mm. high, 0·4 mm. diameter, white, and the conidia are narrow-oval, 4–6 × 1·5 μ. The columella gives off hyphae 2·5 μ diameter, which bear flask-shaped basidia, up to 10 × 2·5 μ, in whorls, the conidia being produced terminally in chains. This does not appear to agree with *Isaria Tinearum* Speg.

Isaria sp. on Orthoptera and Lepidoptera (Text-fig. 2). I have collections of this form on a grasshopper, on a cricket, on cocoons of *Thosea recta*, and on a caterpillar of *Homona coffearia*. Whether these all belong to the same species or not may be regarded as uncertain.

Fig. 2. *Isaria* on locustids, natural size.

The insect is usually covered with a thin, white or cream-coloured film of mycelium, which tends to become glabrous. From this there arise numerous Isarias, each consisting of a cream-coloured or brownish white stalk, up to 2·5 mm. high, 0·5 mm. diameter, expanding upwards, simple or branched, and terminated by a globose, white or pale yellowish head, up to 2 mm. diameter. The heads appear compact, but are powdery on the upper surface, which consists

of loosely intertwined hyphae, bearing conidia laterally. The conidia are oval, often inequilateral, 3–4 × 1·5–2·5 μ.

HIRSUTELLA.

Hirsutella Saussurei (Cooke) Speare. This species (Text-fig. 3) occurs throughout the tropics on hornets, and is well-

Fig. 3. *Hirsutella Saussurei*, on *Vespa cincta*, natural size.

known in all but name. Lloyd refers to it as *Isaria crinita*, the first specimen of this type discovered having been considered part of the insect, which was named *Vespa crinita*. Speare has shown that it belongs to the genus *Hirsutella*, and has given it the name cited above, on the assumption that it is identical with *Isaria Saussurei* Cooke, which was figured, but not named, by Saussure in 1853. According to Cooke, however, the hairs or filaments of *I. Saussurei* are orange, whereas those of the Ceylon fungus are dark brown or black.

Only one collection of this species has been made in Ceylon,

viz. on *Vespa cincta*, Badulla, 1903, by Mr G. Brown. In these specimens the clavae consist of long, black, rigid hairs, radiating in all directions from the body of the host. These hairs are up to 5 cm. long, and over sixty of them arise from one insect. Like the flies attacked by *Cordyceps dipterigena*, the host insect settles on some plant, to which it becomes attached by brown mycelium; while if one of the hairs comes in contact with a leaf or stem, it becomes united to it by a brown pad of mycelium, from which new black hairs may arise. The black hairs are synnemata, composed of longitudinally parallel hyphae, 2–3 μ diameter. They bear basidia, consisting of an ovoid base, about 12 μ high and 7 μ diameter, bearing a single sterigma, 2 μ diameter below, tapering upwards. My specimens are old and mouldy, and do not show conidia or complete sterigmata.

Hirsutella clavispora Petch; *Trichosterigma clavisporum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium covering the insect in a matted glabrous sheet, and spreading out in a fimbriate margin over the substratum. Clavae arising from the mycelium, erect, terete, simple, up to 8 mm. high, 0·35 mm. diameter below, tapering upwards, brownish white (dry), smooth. Basidia with an ovate base, up to 8 μ high, 2–3 μ diameter, rounded or attenuated above, bearing a rigid, simple, filiform sterigma, 5–9 μ high. Conidia hyaline, continuous, clavate, 4–8 × 1–1·5 μ. On a caterpillar attached to a living leaf, Peradeniya, January 1912 (Plate I, fig. 16).

This species does not appear to be related to *Torrubiella ochracea* Pat., the Ceylon analogue of *Cordyceps Sphingum*, as *T. ochracea* has verrucose conidia on the hyphae of the stroma.

Hirsutella arachnophila Petch; *Trichosterigma arachnophilum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium covering the body of the insect and forming a flattened pulvinate, pale yellow, somewhat spongy, tomentose stroma with a fimbriate margin. Clavae arising from the stroma, pallid yellow, cylindric, up to 4 mm. high, 0·15 mm. diameter below, tapering slightly upwards, smooth, simple. Basidia scattered or crowded, globose, 3 μ diameter, or subglobose, up to 6 × 5 μ, each bearing a single rigid, simple sterigma, about 2 μ long. Conidia narrow-oval, continuous, ends acute, 4–8 × 2 μ. On spiders attached to living leaves, Hakgala, March 1922; Peradeniya, March 1909; Peradeniya, March 1917. This species is the conidial stage of *Torrubiella flava* Petch. The specimen from Peradeniya, March 1909, differs in colour, being lilac grey. A similar colour difference occurs in *Gibellula elegans* P. Henn., which is also parasitic on spiders.

Hirsutella citriformis Speare; *Trichosterigma attenuatum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium scanty,

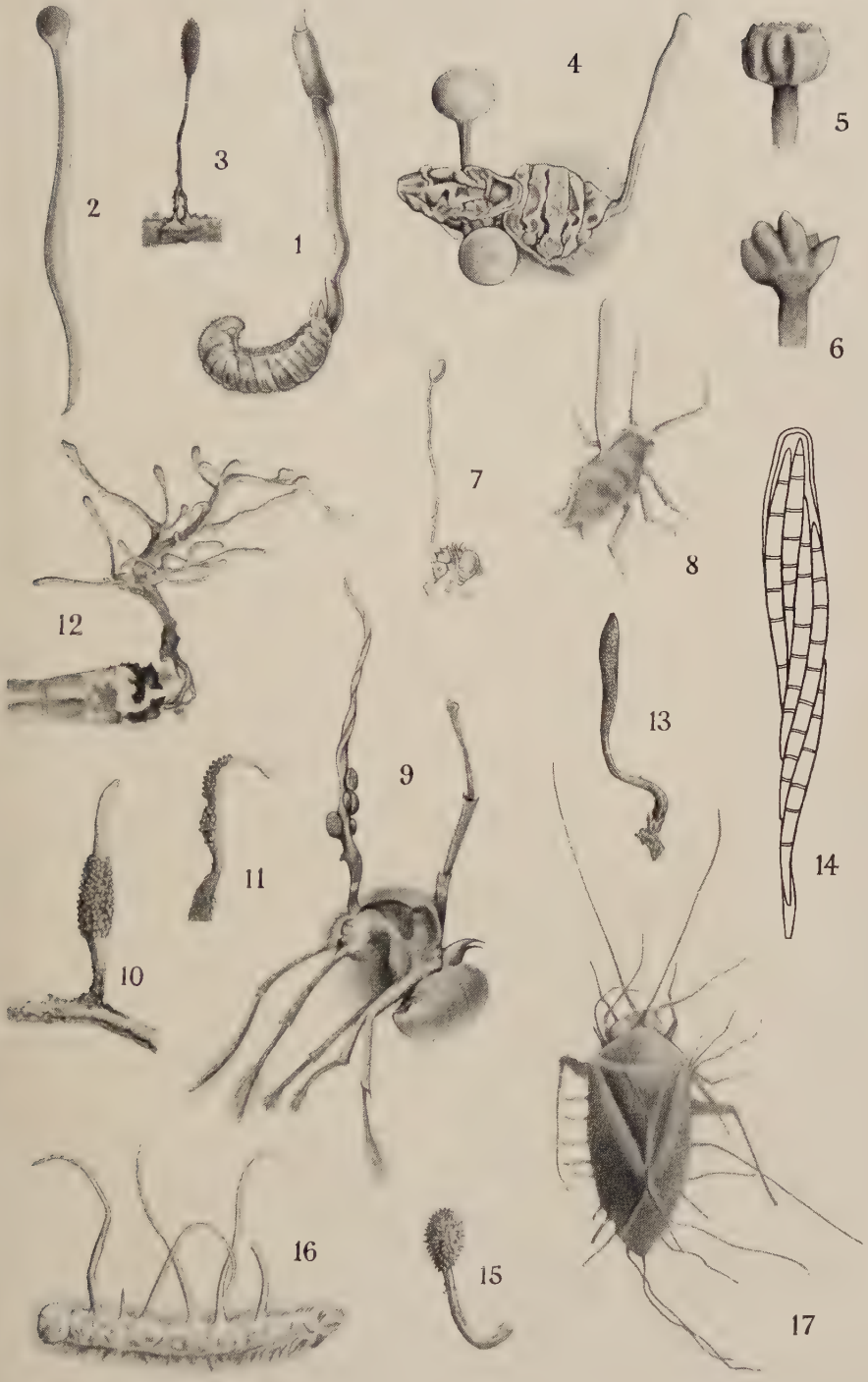
brownish, over-running the host insect. Clavae arising from the body or legs of the insect, usually from the joints, or along the margins of the wing covers. Clavae pale brown (dry), up to 6 mm. long, 0·2 mm. diameter below, tapering upwards to 0·08 mm. diameter, rigid, slightly inflated at the apex, terete, smooth, bristling with hyaline sterigmata when magnified. Basidia oval or flask-shaped, 8–10 × 3 μ, attenuated into a rigid, simple sterigma, up to 26 μ long, 1·5 μ diameter at the base, tapering upwards. Conidia hyaline, continuous, oval or lozenge-shaped, usually acute at each end, 6–7 × 3–5 μ. On a Pentatomid on bark, Hakgala, May 1912. The insect in the only available specimen bears more than forty clavae, but many of them have been broken (Plate I, fig. 17).

Hirsutella floccosa Speare. An example, apparently of this species, was gathered at Hakgala on a leaf hopper, March 1922. Speare states that this species differs from other species of the genus in that the synnemata are merely wart-like outgrowths arising from an external cotton-like subiculum. In the Ceylon example the wart-like outgrowths are lacking. The insect is sparsely covered with white mycelium which spreads from it over the leaf, and the basidia are situated, rather widely separated, on the hyphae. The hyphae are hyaline, 2–3 μ diameter, thin-walled, regular, and septate. The basidia are 5–14 μ high, 3 μ diameter, flask-shaped, tapering into the simple bristle-like sterigma, which is 3–10 μ long. The conidia are narrow-oval, 4 × 1·5 μ, but apparently immature.

GIBELLULA.

Gibellula elegans P. Henn. This species is common on spiders attached to living leaves. The whole fungus may be yellow, or the stroma yellow and the clavae pinkish or flesh-coloured, or the stroma yellow and the clavae lavender. In the latter case, the lavender colour ultimately fades, leaving the clavae pale ochraceous and the conidial heads ashy or whitish. There are no evident morphological differences between these colour forms. The conidiophores may occur on the stroma as well as on the clavae; on the latter, owing to their peculiar origin from loops of hyphae which are stouter than the hyphae of the clava, they have the appearance of being another fungus parasitic on the clavae. The Ceylon species is distinguished from *Sterigmatocystis* by its rod-shaped conidia, 3–5 × 1 μ, with rounded ends. As Vuillemin has shown, the apex of the conidiophore of *Gibellula* is not notably inflated, and the resemblance to *Sterigmatocystis* is merely superficial.

In *Gibellula phialobasia* Penz. and Sacc., the structure of the conidiophore is different, according to the figure and description,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and the fungus appears to be a *Spicaria* or *Verticillium*. The same would appear to apply to *Gibellula eximia* von Höhn., and *G. formosana* Sawada.

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EXPLANATION OF PLATE I.

Fig. 1. *Cordyceps Barnesii*, natural size, from the original painting.
2. *C. gracilis*, natural size.
3. *C. coccinea*. ×2.
4. *C. dipterigena*, typical specimen. ×4.
5. *C. dipterigena*, a variant head. ×8.
6. *C. dipterigena*, abnormal head. ×6.
7. *C. myrmecophila*, natural size, from the Ceylon painting.
8. *C. Blattae*. ×2.
9. *C. unilateralis*. ×4.
10. *C. falcata*. ×2.
11. *C. falcata*. ×2.
12. *C. falcata*, conidial stage. ×4.
13. *C. pruinosa*. ×2.
14. Ascus of *C. Blattae*. ×600.
15. *C. translucens*. ×4.
16. *Hirsutella clavispora*. ×2.
17. *H. citriformis*. ×6.

STUDIES IN ENTOMOGENOUS FUNGI.

(With Plates II, III and 1 Text-fig.)

V. MYRIANGIUM.

By T. Petch, B.A., B.Sc.

The first description of the genus *Myriangium* was published by Berkeley in Hooker's *Lond. Jour. Bot.* iv (1845), p. 72. Berkeley had received specimens from West Australia, and on submitting them to Montagne, he found that the latter had similar specimens from France and Algeria. Consequently the genus was published under joint authorship.

Berkeley's account is as follows:

"A very curious new genus was sent by Mr Drummond amongst the Fungi, allied to *Collema*, but with the outward habit, and in some respects the structure, of a *Dothidea*. One species is identical with a plant gathered by Dr Montagne many years since, without fructification, in the department of the Eastern Pyrenees, on the white mulberry, and has lately been found in Algiers on the *Lentiscus*; the other species has at present been found at the Swan River only.

"*Myriangium* Mont. et Berk.

"Thallus pulvinatus, cartilagineus madore turgescens inaequabilis tuberculatus intus pallescens. Apothecia tuberculiformia primo clausa, tandem aperta plana immarginata. Thalamium (lamina proligera) crassum fuscum multiloculare; singulo loculo ascum unicum fovente, tandem fatiscenti-pulverulentum. Sporidia oblongo-cylindrica octona, octies annulata, annulis interdum quadrate cellulosis, pellucida, ascis sphaericis inclusa.

"1. *Myriangium Duriaei* Mont. et Berk., majus, haemisphaericum, subnitidum. Hab. In Pyr. Or. (Montagne), ad corticem Mori albi; Lentisci in Algeria (Durieu); in Australia in Prov. dicta Swan River (Drummond).

"2. *Myriangium Montagnei* Berk., minus, irregulare, atropurpureum, subtiliter tomentosum. Drumm. n. 262. Hab. Ad corticem in Australia in Prov. dicta Swan River. Drummond.

"The second species resembles extremely *Dothidea examinans* Berk. and Mont.; but not only are the sporidia quite different, the cells containing a single ascus only, but the whole structure of the plant is that of *Collemaceae*.

"The genus bears a certain external resemblance to *Tympanis*, without, however, the least affinity. It is more nearly allied to *Arthonia*, but differs from it in the structure of the thallus and nucleus. It is again allied to *Paulia* Fée (Linn. vol. x, tab. 4), but the fructification is different; and also to *Omphalidium* Mey. and Flotw., in which the asci and sporidia have a very dissimilar form, and the structure of the thallus is quite unlike. Complete figures will shortly be published by Dr Montagne."

In Bory de St Vincent, *Exploration Scientifique d'Algérie*, 1, p. 212 (1846), Montagne gave the following description of *Myriangium Duriaei*.

"Thallus e rimis corticis erumpens, orbiculatus, submonophyllus, minutus, millimetra quatuor diametro attingens rarissimeque superans, plerumque minor, pro ratione crassus, convexus, quandoque et hemisphaericus, rugoso-granulosus, tuber-

culatus, polycoccus, fuscus, intus pallescenti-corneus, ex apotheciis ad varios evolutionis gradus prorsus compositus, et *Collema conglomeratum* referens. Apothecia quam plurima thallum obtegentia, tuberculiformia; tubercula initio capitibus harum spinularum orichalcarum vernacule *camions* dictarum haud absimilia, tandem apice dehiscentia sensimque dilatato-aperta, disco subimmarginato fusco-pulverulento. Thalamium cellulosum, multiloculare, loculis longitrorsum transversimque pluriseriatis, singulo loculo ascum singulum includens. Loculi sphaerici oblongique, $\frac{7}{200}$ millim. diametro aequantes, quorum parietes fere contigui vel $\frac{1}{200}$ millim. vix crassiores ut et totus thallus e cellulis minutissimis compositi sunt. Quisque loculus ascum singulum, ut jam supra dictum fuit, fovet, quo ita repletur ut nullum vix intervallum inter eum et membranulam asci perspici possit. Asci sphaerici eadem cum loculis magnitudine utentes, hyalini, sporidia octona nullo ordine includentes. Sporidia oblonga, utroque fine obtusa et ipsa hyalina, nitore margaritaceo insignia, octies deciesve annulata, annulis quadrate cellulosis, iis *Arthoniarum* haud absimilia."

Montagne stated that he had specimens from the Pyrenees, Algeria, and Australia, and that *Myriangium Montagnei* differed in its purple-black colour and tomentose surface. His figures were drawn from a specimen from the Département Pyrénées Orientales, "Mas de las Abeillas, dans les Albères," but, in contradiction to Berkeley's statement, he gave figures of the spores, showing them as oval or fabaeform. The enlarged figure of a stroma shows close-set, flattened tubercles; that of a vertical section shows two apothecia which have changed colour internally. According to these figures and Montagne's later declaration, the type specimen of *Myriangium Duriaei* is that from Pyrénées Orientales.

Shortly afterwards, another collection of *Myriangium* was sent to Berkeley by Curtis from South Carolina. Berkeley forwarded it to Montagne, who expressed his regret that he had not had this gathering when he published figures of the genus based on the type which he had collected, in 1830, on mulberry near Perpignan. Montagne described this American species as *Myriangium Curtisii* Berk. & Mont., and published an amended generic description, in Cent. VI, No. 70, *Ann. Sci. Nat.*, Sér. 3, XI (1849), p. 245, as follows:

"COLLEMACEAE.

"*Myriangium* Berk. et Montag.

"Char. emend. Thallus orbiculatus, tuberculatus, aut inaequabilis ambitu plicato-striatus, gelatinosus, madore tur-

gescens, atro-fuscus, intus pallescens. Apothecia, imperfecta tuberculiformia immarginata, perfecta vero scutelliformia, a thallo marginata, primo clausa, dein aperta, thalamium includentia crassum, concolor, fuscum, multiloculare, loculo singulo ascum singulum fovente, tandem fatiscenti-pulverulentum. Sporidia oblonga, octona, octies annulata, annulis quadrate cellulosis, pellucida, ascis ex ovoideo sphaericis inclusa. Myriangium Berk. et Montag., in Lond. Journ. of Bot., febr. 1845, p. 72, et Fl. d'Alg. 1, p. 213, t. 19, fig. 2.

"*Myriangium Curtisii* Berk. et Montag. mss.; thallo plano orbiculari inaequabili ambitu radiato-plicato atro-fusco, apotheciis scutelliformibus margine elevato integerrimo instructis, disco subconcolori. Hab. Ad ramos fruticum Carolinae inferioris a Rev. M. A. Curtis, cui libente animo dicamus, lectum.

"Desc. Thallus orbiculatus, in plagulas parvulas 3 ad 5 millim. diametro aequantes expansus, cartilagineus, fragilis, atro-fuscus, centro inaequabilis, ambitu tenuiter breviterque radioso-plicatus, intus sordide olivasceus, cortici arcte applicatus. Apothecia pro ratione ampla, majora millimetrum lata, sessilia, haud adnata, elevato-marginata, scutelliformia, concaviuscula, margine thallode integerrimo instructa, disco subconcolori. Thalamium crassum, tertiam millimetri partem adaequans, cellulosum, multiloculare, loculis multiseriatis, singulo ascum unicum fovente. Asci obovato-oblongi, 0·04 millim. longi, 0.03 millim. crassi hyalini, sporidia suboctona (immatura) includentes."

It would appear from Montagne's remarks that he considered this species distinct from *M. Duriaei*, because of the shape of the apothecia. "Elle en est en effet le représentant le plus parfait, puisque ses apothécies sont en grande partie libres en dessous et hautement marginées par le thalle."

In *Syll. Crypt.* (1856), pp. 380, 381, Montagne repeated the foregoing generic description with verbal emendations. He enumerated two species only, viz. *M. Curtisii* and *M. Duriaei*. Following "disco subconcolori" of his previous description of *M. Curtisii*, he added, "ascis obovato-oblongis, sporas 8 (immaturas) foventibus," and omitted the details of the second paragraph. *M. Duriaei* was described as, "Thallo e cortice erumpente, orbiculato, convexo-hemisphaerico rugoso-granuloso, polycocco, ambitu haud effigurato; ascis sphaericis, sporas 8 oblongas tandem quadrate cellulosas includentibus. Hab. Ad corticem *Mori*, in Pyrenaeis orientalibus, primus (1830) Ipse legi; dein in Algeria, ad corticem Lentisci: Durieu; apud Melodunum: Roussel; tandem in Australia, cum *Myriangio Montagnei* Berk., l.l.c.c.; Drummond."

Berkeley, in referring to Myriangium in his *Introduction to*

Cryptogamic Botany (1857), p. 408, stated, "In the two original species the disc is mostly veiled; but in *M. Curtisii* Berk. and Mont., which is by far the finest, it is as open as in any *Collema* or *Leptogium*."

In *Ann. Sci. Nat.* Sér. 4, III (1855), p. 146, Nylander listed *Myriangium Duriaei* from Chili. He described it as "Thallus cum apotheciis confluens in pulvinulos piceo-atros opacos nodulosos, depressiusculos, intus fere concolores obscuros; thecae sphaericae vel ellipsoideae, sporae 8-nae oblongae, non coloratae, longitudine 0·020–25 millim., crassitie 0·010–12 millim., transversim tenuiter 5-divisae, addita saepius divisione longitudinali plurimas transversas percurrente, omnibus vero his septulis sat irregulariter varieque dispositis. Protoplasma thecis inclusum iodo vinose fulvescens. Ad cortices arborum, saepe supra thallum aliorum lichenum crustaceorum. Genus paradoxum, Arthoniis in serie Lichenaceorum potissime affinitatem quandam offerens."

In *Prodromus Lichenographiae Galliae et Algeriae* (1856), Nylander included *Myriangium Duriaei* with the note, "Plantula omnino paradoxa, nec inter lichenes locum suum haud parum dubium servans nisi ob virescentiam obscuram sectionis thalli. Ad corticem arborum, praesertim ulmorum, ad ramos potissime, saepeque ibi supra thallum lichenum crustaceorum, in Gallia et in Algeria, verisimiliter non rarum, sed facile praetervisum."

In *Synopsis methodica Lichenum* (1858), Nylander gave the following account of the family *Myriangiacei*:

"FAMILIA II—MYRIANGIACEI.

"Thallus coloris obscuri, nigricantis parvus, nodulosopulvinatus, texturae cellulosae aequalis (strata nulla exhibentis), sectione opacus, obscurus, friabilis. Apothecia formae peculiaris sublecanorinae, thalamio similiter celluloso ac thallo, solum illo discolore; thecae in loculis thalamii sphaeroideis aut sphaeroideo-ellipsoideis aut late ovoideis inclusae sporis 8-nis oblongis irregulariter septatis vel fere murali-divisis incoloribus, in thalamio absque ordine farctae, juniores supra pariete crasso (ut in Arthoniis).

"Momentis plurimis secedunt plantulae huc pertinentes et a Collemaceis et a Lichenaceis, his tamen majorem praebent affinitatem textura anatomica, ad illos quodammodo vergunt facie externa. Maxime singulare iis adest thalamium cellulosum cavitatibus theciferis excavatum rotundatis (inordinate seriebus 2–5 superpositis vel conferte inspersis), ut lamina tenui visum quasi cribrosum adpareat.

"Species modo binae cognitae (vel tres?) [footnote—*Myri-*

angium inconspicuum Babingt., L. New Zeal. p. 46, t. 128 est *Arthonia lurida* Ach., cur parum commune habet cum genere Myriangio.—*Myr. Montagnei* Berk. a me non visum], quarum altera quoque in Europa viget. Sunt corticolae, saepeque supra thallos Lichenaceorum occurrunt.

"Trib. 1.—Myriangiei.

"Unica quum sit hujus familiae tribus nullas addendas habemus notas iis, quae jam pro familia afferuntur.

"1. *Myriangium* Mnt. et Berk.

"Nec, ob eandem rationem, hic necesse est, ut definitioni familiae jam datae aliquid adjiciatur; quare ad definitionem praecedentem relegamus lectorem. Spermogonia adhuc ignota.

"1. *M. Duriaei* Mnt. et Berk. in Hook. Jour. Bot. 1845, p. 73, DR. Alger. p. 214, f. 2*, Desmaz. Cr. Fr., éd. 2, 1598, Nyl. Addit. Cr. Chil. in Ann. sci. nat., 4, III, p. 146; *Collema glomerulosum* Tayl. in Mack. Hibern. 2, p. 108 (non Ach.).

"Thallus niger opacus parvus (latit. 2–4 millim., altit., 0·5–0·6 millim.), tuberculato-glomeratus vel noduloso-confluens, saepe depresso-pulvinatus, glomerulis his sparsis; apothecia in nodulorum apice sita concolora, minuta, parum vel vix impressa; sporae oblongae vel oblongo-ovoideae varie septatae, longit. 0·020–36 millim., crassit. 0·009–0·016 millim.

"Ad cortices arborum, saepe supra thallum aliorum Lichenum crustaceorum vulgarium in Europa ad fraxinos, ulmos (praesertim ad ramos), etc.; vix nisi in Gallia et Hibernia adhuc observatum, sed verisimiliter late distributum, nec nimis rarum. Etiam in Algeria, ad lentiscos. In America (e Mexico in Chili) quoque et in Australia (ex hb. Hook.).

"Si nomen glomerulosum Tayl. purum fuisset, id speciei huic conservassem, nam evidenter prioritatem habet; utpote jam receptum et cognitissimum M. Duriaei forte nomen retinendum. Notis jam datis vix aliquid majoris momenti addendum. Protoplasma thecarum iodo vinose fulvescens.

"2. *M. Curtisii* Mont. et Berk. in Ann. sci. nat., 3, XI, p. 245, Mnt. Syll. p. 381. Thallus niger vel fusco-niger opacus parvus (latit. 3–5 millim.), inaequalis vel granuloso-inaequalis, depresso-pulvinatus, ambitu interdum sublobatulo-effiguratus; apothecia concolora vel subconcolora plana opaca (epithecium extus subsimile epithallo), saepe subrugulosa, majora (latit. circa 1 millim.), lecanorina, margine thallino integro cincta: sporae oblongae fere murali-divisae, longit. circa 0·018 millim., crass. 0·008 millim. Ad ramos fruticum in Carolina inferiore, ex auctt. citatis et speciminibus in herbariis variis.

"Facile dignotum a praecedente mox forma apotheciorum

externa. Thecae seriebus pluribus inordinatis superpositis thalamium lamina tenui visum crebre cribrosum reddit; hae minores et crebriores quam in praecedente.

"Non vidi *Myriangium Montagnei* Berk. in Hook. Journ. Bot. 1845, p. 73, nimis breviter verbis sequentibus indigitatum: 'minus (quam *M. Duriaei* B. et M.) irregulare atropurpureum subtiliter tomentosum. Drumm. n. 262. Hab., ad corticem in Australia, in provincia dicta Swan River.'"

In 1886, Millardet published a paper "Des Genres *Atichia*, *Myriangium*, *Naetrocymbe*. Mémoire pour servir à l'histoire des Collemacées" (*Mém. Soc. Sci. Nat. Strasbourg*, VI). In *Myriangium*, he had examined European specimens from Cherbourg and from Italy, and American specimens, Lindig 2583, from New Granada. He found that in the American specimens the cortical zone consisted of long narrow cells, with their greatest diameter perpendicular to the surface, but in the European plant this cortical zone was absent, or scarcely distinct: in the American examples, the spores measured 24–32 × 9–15 μ, and in the Italian examples, 25·7–35 × 9·6–14 μ. Of his figures, Nos. 23, 24, 27, 28, and 29 are from the American specimens, and 25 and 26 from the Italian examples. Some of these figures have been reproduced in Engler-Prantl, lettered *A* to *E*; 25 = Engler-Prantl, *C*; 23, 24, 27, 29 are *A*, *B*, *D*, *E*.

Millardet noted that the apothecia of the European form were poorly developed in comparison with the American, but he regarded the two as identical. He also noted that here and there on the surface, and more rarely in the interior, there was sometimes a green coloration due to a *Protococcus*, but in his summing up he stated that *Myriangium* does not possess chlorophyll at any stage.

The specimen, Lindig 2583, was issued as *Myriangium Curtisii*. Millardet did not cite this specific name, nor venture into the question of nomenclature, but his results would make *M. Curtisii* a synonym of *M. Duriaei*, presuming that the specimens had been correctly named.

In *Flora* (1869), p. 298, Nylander pointed out that Millardet's figures Nos. 23 and 24 belonged to *Myriangium Curtisii*, according to the naming of the specimens.

Tuckerman, in *Genera Lichenum* (1872), p. 141, has the following note on the subject.

"*M. Duriaei* Mont. & Berk., in Fl. Alg., the original species (Pyrenees, Montagne! Mass. Lich. Ital. n. 27! Rabenh. Lich. Eur. n. 635!) has been traced already to Algeria, to Australia, and South America (Brazil, Pabst! Lindig Herb. N. Gran., n. 2583, 2669, 2789!) and, reaching Cuba (Wright!), should be

likely to appear also within our southern boundaries. And the plant (*M. Curtisii* Mont. & Berk.) which does occur here, and extends northward along the coast (Carolina, Curtis, Ravenel; Alabama, T. M. Peters; Massachusetts, C. F. Sprague, H. Willey), though certainly noticeable, at least in its best conditions, for general luxuriance—the larger thallus becoming also effigurate, and the apothecia perhaps more perfectly lecanoroid—is by no means satisfactorily distinguished from the other. The 'striate-plicate' circumference found by Montagne in both his species, and re-affirmed by Massalongo of *M. Duriaei*, may in fact be considered as implying the at length certainly striking, but inconstant lobation of the North American *Myriangium*; and one of the New Granada forms of the older species (Lindig n. 2583), as determined by Nylander, is quite as distinctly effigurate as the Carolina plant. [Footnote.—It is, in this connection, observable, that both the species, as defined, are now recognised as European plants;—*M. Duriaei* Millard. in Mém. Soc. Sci. Nat. Strasb., being referred by Dr Nylander (Flora, 1869, p. 298) to *M. Curtisii*.] The apothecia are similar in both, and similarly modified; and the supposed diversity in the thekes (Mont. Syll.) is far from characteristical. And this last remark applies also to the results obtained by Nylander (Syn.) from the specimens before him; neither the thekes of the Carolina plant, nor its spores differing, in a wide view, in any important respect, from those of *M. Duriaei*. [Footnote.—Very commonly roundish-ovoid, or 'ovate-ventricose' (Mass.) and not much exceeding 0·050 mm. in their longest diameter, the thekes of *Myriangium* also occur oblong, or 'obovate-oblong'; and the latter condition was understood by Montagne to be characteristical of his *M. Curtisii*. But this exceptionally elongated state, which I have observed to measure 0·069–92 mm. in length by 0·023–35 mm. in width, is by no means confined to the North American specimens, or even more frequent in them, spores of the Carolina plant averaging 0·025–35 mm. in length by 0·007–11 mm. in width.] The lobulate margin of the North American plant is at length quite free from the substrate, when the underside of the fringe is seen to be entirely similar in all respects, whether of configuration, colour, or smoothness, to the upper; an observation not perhaps wholly without bearing on the question of the affinity of *Myriangium*."

With regard to the foregoing, it must be noted that Tuckerman misinterpreted Nylander's statement in *Flora, loc. cit.* Nylander only pointed out that Millardet's figures 23 and 24 belonged to a specimen which had been identified as *Myriangium Curtisii*. And the statement that the latter species had been

recognised to be European is also in error, for Millardet's figures in question were drawn from an American specimen. This is the specimen which Tuckerman lists under *M. Duriaei* and refers to as one of the new Granada forms of the older species, Lindig, n. 2583. Tuckerman was also unfortunate in conveying the suggestion that Nylander regarded *M. Duriaei* and *M. Curtisii* as identical, for Nylander (*Synopsis*) did not give measurements of the asci, and stated that *M. Curtisii* was easily distinguished from *M. Duriaei* by the shape of the apothecia. Further, although it is true that Montagne (*Sylloge*) gave the asci of *M. Duriaei* as spherical, and those of *M. Curtisii* as oblong-ovate, he did not state that that difference was the distinguishing character between the two species. Reference to Montagne's original description shows that he was especially impressed by the differences in the size and shape of the apothecia, as was evidently perceived by Nylander (cf. Plate II, figs. 1 and 6).

Bornet, in "Recherches sur les gonidies des lichens" (*Ann. Sc. Nat.*, Sér. V, XVII (1873), p. 95), wrote, "Le *Myriangium Duriaei* Berk. et Montg., type de la tribu des Myriangiés, n'est pas compris dans l'énumération précédente, parce qu'il ne contient aucune trace de gonidies, ni dans les pulvinules qui renferment les thèques, ni dans le mycélium souscuticulaire, ce qui semble l'exclure de la classe des Lichens."

In *Synopsis North American Lichens* (1882), p. 261, Tuckerman listed "*Myriangium Duriaei* (Mont. & Berk.) Tuckerman, Gen. Lich., p. 140" with the synonyms "*M. Duriaei* & *M. Curtisii* Mont. & Berk., in Mont. Syll. p. 380; Nyl. Syn. 1, p. 139, t. 4, f. 1–5."

In *Bull. Torrey Bot. Club*, X (1883), p. 76, Ellis and Everhart described *Cenangium asterinosporum* E. & E., which occurred on living branches of *Vaccinium corymbosum*. Specimens were issued in Ellis, *N. A. Fungi*, No. 1279.

In *North American Pyrenomycetes* (1892), Ellis and Everhart published the name of the original species as *Myriangium Durieui*, the name of the collector of the Algerian specimen being Durieu, and gave the following synonymy:

Myriangium Curtisii Mont. & Berk., in Mont. Syll. p. 380.
Pyrenotheca yunnanensis Pat., Bull. Soc. Bot. Fr. p. 155. 1886.
Phymatosphaeria yunnanensis Sacc., Syll. VIII, p. 847.
Cenangium asterinosporum E. & E., in N. A. Fungi, 1279.
? Phymatosphaeria brasiliensis Speg., Fungi Puigg. p. 174.
? Phymatosphaeria abyssinica Pass., Nuovo Giorn. Bot. Ital. VII, p. 118.

Ellis and Everhart added the note:

"The measurements of asci and sporidia are from the Florida specimens; those from more northern localities have the sporidia mostly smaller. The Florida specimens (*M. yunnanensis*) also

differ from those found in the northern States in the absence of any free-margined thalloid effigurate subiculum....We have seen no specimens of *Phymatosphaeria abyssinica* and *P. brasiliensis.*"

With regard to Ellis and Everhart's synonymy, it would appear that the reference of their *Cenangium asterinosporum* to *Myriangium Duriaei* was made by themselves, and that they followed Tuckerman in similarly referring *M. Curtisii.* As for the inclusion of *Phymatosphaeria yunnanensis,* it would seem that Florida specimens had been identified as that species, and that having found that the specimens were *Myriangium Duriaei,* Ellis and Everhart concluded that the two names were synonymous. But I have been unable to find any record of *Phymatosphaeria yunnanensis* in any list of Florida fungi, or to discover who assigned Florida specimens to that species. In the original description, only Yunnan is given as the locality.

Starback, in *Bihang K. Svenska Vetensk.-Akad.* XXV, III, No. 1 (1899), described the "Ascomyceten der ersten Regnellschen Expedition," and dealt with the *Myriangales* on pp. 37–42. He stated that he could find no difference between *Myriangium* and *Phymatosphaeria* Pass., but did not record that he had examined the type specimen of the latter. He examined *Myriangium Duriaei* in Rabenhorst, *Fungi Europaei,* No. 4067; this, however, is an American specimen. In describing a new species, *M. thallicolum* Starb., he referred to *M. yunnanense* (Pat.) and *M. Duriaei* Mont. & Berk., apparently regarding the two latter as distinct species.

In *Hedwigia,* 39 (1900), pp. 97, 98, Rehm gave the following synonymy:

Myriangium Duriaei Mont. & Berk., Hook. Bot. Journ. p. 73. 1845.
Syn. Phymatosphaeria abyssinica Pass., f. Abyss. p. 188, t. v, f. 11. Cfr. Sacc., Syll. 1, p. 72.
Phymatosphaeria yunnanensis Pat., Bull. Soc. Bot. Fr. p. 156, 1886, sub *Pyrenotheca*; Sacc., Syll. Discom. p. 847.
Myriangium Curtisii Mont. & Berk., Ann. Sci. Nat. 3, XI, p. 245.
Cenangium asterinosporum E. & E., Bull. Torr. Bot. Club, X, p. 76.
Collema glomerulosum Tayl., Fl. Hibern. pt 2, p. 108 *sec.* Mudd, Man. Brit. lich. p. 50, Pl. I, f. 10, sub *M. Duriaei.* Cfr. Nyl. Syn. lich. 139, t. 4, f. 1–5 egregie.

Rehm did not state on what evidence this synonymy was based. It was cited by von Höhnel on the specimens of *M. Duriaei* from Java distributed by him. In Fragmente, No. 244, von Höhnel wrote that *Pyrenotheca yunnanensis* Pat. and *Phymatosphaeria abyssinica* Pass. were, "wie bereits bekannt," synonymous with *Myriangium Duriaei* Mont. and Berk., and referred his readers to Rehm, *loc. cit.*

Structure.

Berkeley, in the original generic description of *Myriangium* (1845), stated that the stroma was "cartilagineus madore turgescens," and Montagne, in the amended generic description published in 1849, described it as "gelatinosus madore turgescens." Taylor, however, in recording *Myriangium Duriaei* from Ireland (1836) under the mistaken identification, *Collema glomerulosum* Ach., noted that "it alters very little its hue or size by being wet"; and Wilson (1892) stated with regard to *Myriangium dolichosporum* (= *M. Montagnei*) that it did not "appreciably increase in size when moistened as the *Collemacei* do." In fact, in none of the species of *Myriangium* examined during the preparation of this account is the stroma gelatinous, nor does it alter its size or shape on being wetted.

In the species of *Myriangium* which are parasitic on scale insects, the stroma consists of a basal disc, either continuous or lobed, from which arise numerous erect processes (Plate II, figs. 1–10; Plate III). In European forms of *M. Duriaei*, the basal disc is usually well developed and flattened-pulvinate, but in tropical examples of the same species it may be merely a thin film. The processes may be pulvinate, or turbinate, or nail-shaped, *i.e.* with a broad circular top on a narrow stem-like base. In some examples the fertile stroma lacks processes and is simply pulvinate (Plate III, fig. 3). All these forms may occur in the same species, and it does not appear possible to establish species on the shape either of the processes or of the basal stroma only.

The stroma is composed of thick-walled hyphae which run more or less radially from the centre in the basal portion, and vertically upwards in the processes. In the young processes of *M. Duriaei*, the internal tissue is often plainly vertically fibrillose, but this character may be subsequently obliterated by the intermingling of the branches of the hyphae and their fusion into a compact tissue. The hyphae, however, are not so strongly contorted, nor so firmly united to one another, as in the stromata of *Hypocrella* or in sclerotia, and sections readily separate into short lengths, or joints, of hyphae under pressure, while many specimens show a fibrillose structure when broken.

The hyphae (Text-fig. 1) are from 2·5–6 μ diameter in *Myriangium Duriaei* and 1·5–5 μ in *M. Curtisii*. They are slightly irregular and very thick-walled, a hypha 6 μ diameter sometimes having an irregular discontinuous lumen only 1·5 μ diameter. Owing to the strong thickening of the walls, septa are not evident, but their position is usually indicated by a constriction of the wall, and the hyphae readily break up into joints 10–12 μ long. The hyphae branch dichotomously (Text-fig. 1),

and ultimately pass into similarly branching chains of thick-walled cells (Text-fig. 2), either spherical, 4–14 μ diameter, or oval, 10–14 × 9–10 μ (*M. Duriaei*), or 7–11 × 5–8 μ (*M. Curtisii*). Both forms of hyphae occur in all parts of the stroma, but the spherical cells are the more numerous towards the exterior. The lumen of the spherical cell is usually very small, 1–3 μ. In the upper part of the stroma, however, the cell wall in many cases is not so strongly thickened, and may be only 1–2 μ thick. In

Hyphae from the stroma of *Myriangium Duriaei*. × 1000.

M. Thwaitesii nearly all the cells of the stroma are oval or globose.

The hyphae increase in length by apical or lateral growth from the terminal cell (Figs. 4, 5). In some cases, the new cell is thin-walled at first; in others it appears to be thick-walled from the beginning. The contents of the terminal two or three cells often remain continuous until the apical cell is well developed. In some instances, a cluster of spherical cells appears

to be borne at the apex of an elongated hypha, but as all the cells of the stroma naturally adhere to one another, this appearance is probably fictitious. A large number of the terminal cells have their contents divided transversely into two semi-oval masses, separated by a thick wall (Fig. 3), but it has not been possible to trace any further division of these into two distinct cells.

The stroma is moderately hard, but in general it easily breaks transversely, and hence the processes and apothecia are often lacking in herbarium specimens. This transverse fragility is perhaps to be associated with the readiness with which the hyphae separate into joints. The stromata of different species, however, differ in this respect, and while sections of *M. Duriaei* break up under the knife, the stroma of *M. Montagnei* is of a cheesy texture and readily furnishes continuous sections. In section, the stroma appears parenchymatous, being composed of narrow, irregular, elongated cells (the long segments of the hyphae), and angular, more or less isodiametric cells (the spherical or oval segments of the hyphae). The exterior layers may consist of polyhedral cells, like those in the interior, or of subrectangular cells, situated with their longer axes perpendicular to the surface. Millardet noted that the latter form of cortical layer was better developed in South American examples of *M. Duriaei* than in European examples. I have, however, examined British specimens of that species in which the cells at the exterior of the stroma were more or less rectangular, and showed a radial arrangement to a depth of 75 μ from the surface.

Berkeley and Montagne considered *M. Duriaei* a lichen. In forming that opinion, they may perhaps have been influenced by the internal colour of the stroma of that species, which, except in old examples, is distinctly green. The green coloration, however, is not due to an algal constituent of the stroma, but to a granular green deposit between the hyphae. In general, this deposit is a thin film, but in places it may be up to 6 μ thick; it does not exhibit any definite structure. Chlor-zinc iodide stains these intercellular masses deep brown, and they assume a brown tint with eosin; with gentian violet they stain deeply and appear black. When the stromata are crushed in alcohol and the mixture heated, a feebly greenish extract is obtained, but this does not give any reactions for chlorophyll. These results agree with those of most of the previous workers on *Myriangium*. The green coloration is not due to an alga, and the stroma does not contain chlorophyll or gonidia. It is frequently possible to find algae associated with the stromata of *Myriangium*, usually in groups of four or more cells, but these

are purely external and their presence is accidental. In *M. Curtisii* and *M. Montagnei*, the stroma is pale brown or yellow-brown internally: in *M. Thwaitesii*, it is white, or almost white, owing to the deficiency of colouring matter except at the exterior. In the latter, the intercellular substance stains yellow-brown with chlor-zinc iodide, and pink with eosin.

The well-known figure of the longitudinal section of the stroma of *M. Duriaei*, published by Millardet and reproduced in Engler-Prantl, *Natürlichen Pflanzenfamilien*, I, i, p. 320, appears to show a parenchymatous structure, composed of cells having thin walls. That interpretation, however, is not correct. The apparently dark cell walls seen in a section are the lines of the green substance between the cells, or segments of the hyphae. The actual cell wall is very thick and the lumen of the cell is small. In many of the cells, especially towards the base of the stroma, there is a small bright spot, about 2 μ diameter, which at first sight resembles a pore in the cell wall; but, on staining the section, it is found that that is the cell lumen, the wall of the cell being thickened to such an extent that the cell is almost solid. A careful examination of Millardet's figure will reveal these minute lumina in some of the cells towards the base. The structure, however, is the same throughout, though the walls of the cells in the upper part of the stroma are usually not so strongly thickened as those of the cells at the base.

The shape of the cells at the exterior of the stroma has already been referred to. These become blackened or browned and form a black cortex. As a rule, this cortex is thin, but in some American examples of *M. Duriaei* it attains a depth of 0·1 mm. The cells of the cortex are more firmly united to one another than those in the interior of the stroma.

When old, the internal colour of the stroma may change. In *M. Duriaei* it becomes purple-brown or purple-black. At the same time the internal tissue becomes friable.

The stromata of the species of *Myriangium* which are parasitic on scale insects are sclerotioid, the thick-walled hyphae being rather feebly united to one another except in the cortex. With chlor-zinc iodide, the cell walls are scarcely stained, but the cell contents and the intercellular substance are stained deep brown. There is no cellulose reaction. Eosin stains the cell contents pink, but the cell wall is not stained. Sudan III in glycerine does not stain the cell wall, but colours the contents and the intercellular substance red-brown. Gentian violet stains the cell wall violet-blue, the intercellular substance becoming almost black.

In the stroma of *M. Pritzelianum*, which is parasitic on plants, the cell walls are not exceptionally thickened, and the cells of

the pseudoparenchyma are all of the same general shape. The stroma is red-brown internally, turning black from the base upwards, the tissue round the asci remaining red-brown.

The fructifications of *Myriangium* are formed at the apices of the processes (Plate III). They have been generally known as apothecia, but their development is scarcely that of a true apothecium and in many instances nothing resembling an apothecium is produced. At a certain stage of development, the surface of the apex of the apothecial process may weather away. The cortex becomes minutely lacunose, or appears matted-tomentose owing to the disappearance of minute particles here and there. This disintegration occurs on no definite plan; it may begin at the margin or at any point on the upper surface, and there does not appear to be any definite abscission layer beneath the cortex which weathers off. In some instances, the tissue separates more or less in scales at the limit of the ascigerous zone; in other cases, the initial cracks penetrate into the ascigerous region; while, perhaps more generally, the initial weathering of the surface layers does not extend to that region. When this disintegration is completed, a cup-shaped depression (Plate II, fig. 4) is left at the apex of the process. The margin of the cup is usually irregular, and the disc is parenchymatous, like the tissue which has weathered off. Thus, this dehiscence does not expose a layer of asci; the latter are still embedded in the parenchymatous tissue.

In *M. Duriaei*, the open apothecium is greenish black; this is due to the green colour of the interior and the gradual blackening of the exposed tissue. In *M. Montagnei*, the open apothecium is brown, at least in the larger examples.

The shape of the apothecium is highly variable in the one species. In *M. Duriaei*, it is typically cup-shaped, concave with a narrow plicate margin, but it may be convex without a distinct margin (Plate II, fig. 3). In *M. Montagnei*, it may be cup-shaped, concave with a stout rounded margin, or broadly concave with a narrow margin, or broadly convex without a differentiated margin (Plate II, figs. 8, 9, 10). Naturally, in this connection one thinks of the smaller Pezizas, which may be concave at first or in dry weather, but become convex in wet weather or through continued growth of the hymenial layer. But the apothecia of *Myriangium* do not notably change their shape with weather conditions, nor does there appear to be any further growth of the disc after the surface has disintegrated. The different forms of the apothecium appear to be due merely to the different sizes attained by the apothecial processes before the upper layer disintegrates, and to the extent of this disintegration over the apex.

In many cases, however, open apothecia are not formed. Asci are produced within the closed processes, and the stroma then decays, its internal tissue changing colour and the cortex breaking up generally. In British examples of *M. Duriaei*, the formation of open apothecia appears to be the rule. On the other hand, open cup-shaped apothecia are practically lacking in tropical examples of that species, but the closed processes contain mature asci. Specimens of the same species from Florida usually resemble the tropical forms in that respect, but some gatherings from that country include open cup-shaped apothecia, similar to those of the British examples.

It is remarkable that there is no definite relation between the formation of apothecia and the development of the asci. The British examples which bear open apothecia may not contain any asci, while tropical examples which do not bear open apothecia contain mature asci in the closed processes. In a stroma of *M. Curtisii*, a large, widely-open apothecium, several millimetres in diameter, was quite sterile, while an adjacent closed process contained asci. It is not possible to determine with certainty by mere inspection whether a given stroma is fertile or not.

Myriangium Pritzelianum, which is parasitic on plants, apparently does not produce open apothecia, judging from the available specimens.

It would appear from the foregoing that the apothecium is not a constant or necessary character of *Myriangium*. It might even be regarded as an accidental feature, dependent upon the manner in which the stroma begins to decay. The stroma may produce asci in its processes and decay as a whole without the formation of open apothecia. It might be suggested that the difference between the temperate and tropical examples is dependent on a more rapid development and decay of the stroma in the latter. In the temperate examples of *M. Duriaei*, the processes are usually longer, and disintegration of the cortex takes place at first over a limited area, *i.e.* the apices of the processes, the remainder of the stroma retaining a glabrous surface: in tropical examples, the processes do not develop to such an extent before ascus formation occurs, and the whole surface of the stroma soon becomes dull and pulverulent.

The asci (Plate II, figs. 11–13) are embedded singly in the parenchymatous tissue. They are usually elliptic or spherical, sometimes with a small conical projection at the base, but in *M. Thwaitesii* they are clavate or pyriform, with a distinct foot (Plate II, fig. 18). The individual asci are separated from one another by a layer of parenchymatous tissue which may be only 4 μ broad, but is usually 16 μ or more. The parenchymatous

tissue which encloses an ascus is more compact and firmly fused together than that elsewhere and forms a kind of sheath, but this would appear to be due to the pressure of the developing ascus; there does not appear to be any "ascogenous cell" in which the ascus is developed. In *M. Duriaei*, the asci occur irregularly scattered through the parenchyma in a cup-shaped, or globose, region which may descend almost to the base of the process. In *M. Montagnei* and in the available specimens of *M. Curtisii*, they occur usually in a few layers in a lenticular or laterally oval zone, which becomes a narrow zone parallel to the surface in widely-open apothecia. In general, this ascigerous zone is paler than the surrounding parenchyma.

The asci vary considerably in size, and this variation is not necessarily correlated with the size of the spores. This is especially marked in *M. Duriaei*. In that species, some of the asci are spherical and the spores almost completely fill the ascus; others are elliptical, and double the size of the former, but their spores are confined to the lower part of the ascus, where they form a spherical or elliptical mass, which may be only slightly larger than the mass of spores in the spherical ascus (Plate II, figs. 11, 12, 13). It is not easy to determine the limits of the wall of the ascus, but measurements on broken asci show that the actual wall is comparatively thin, varying from 1 to 3 μ. The spores are embedded, in no particular order, in a small quantity of protoplasm and form a globular mass, while the space between the spore cluster and the wall of the ascus is filled by a homogeneous, hyaline substance of rather firm consistency, which, when the ascus is broken under pressure, sometimes emerges in a continuous sheet. The cluster of spores is contained in a cavity in this plasma; there is no second wall round them. With iodine, the spore cluster stains yellow-brown, but the ascus wall and the hyaline plasma do not stain. In one instance, in a section of *M. Duriaei* which had been subjected to pressure, the hyaline plasma had emerged from the broken ascus in a cylindrical column, containing the spores in a row and resembling a cylindrical ascus, the resemblance being increased by the prolongation of the spore plasm into the apex of the hyaline plasma (Plate I, fig. 14). An identical prolongation has been observed in a case in which the whole of the contents of an elliptic ascus had been extruded, but in this latter instance the hyaline plasma retained its elliptic form, and the spores were situated towards one end in the normal irregular cluster. It is not uncommon to find, in sections disintegrated by pressure, the contents of an ascus, retaining their original shape, but destitute of the ascus wall, or with the wall collapsed at the base of the mass; or asci from which the spores have been extruded, but to which the

hyaline plasma is still attached (Plate II, fig. 20). In the latter case, the hyaline plasma is usually oval or tongue-shaped, but it may be more or less cylindric. As a rule, no cavity is observable in the hyaline plasma after the spores have escaped; in some cases, however, a small quantity of the excess spore-plasm may remain embedded in it.

The cylindrical ascus-like formation would appear to be uncommon. It would seem probable, however, that Tuckerman's elongated asci were of this nature. Its occurrence cannot be a universal phenomenon, since the spherical asci, in general, contain only a small amount of this hyaline plasma.

In Engler-Prantl, *Pflanzenfamilien*, I, i, p. 320, it is stated that the asci dehisce in consequence of the swelling of the inner layer of the ascus wall (der innern Membranschicht). Presumably this "inner layer" is the substance referred to above as hyaline plasma. It appears to be free from the ascus wall, though no line of separation can be detected in the unbroken ascus. It is possible that dehiscence of the ascus is effected in the manner indicated. But no observations have been made which would indicate that the spherical asci expand into elliptic asci owing to the swelling of the hyaline plasma. Immature asci may be either spherical or elliptic, and a comparison of immature and mature asci, *i.e.* those in which the spores are not yet formed and those in which they are fully developed, suggests that the space occupied by the hyaline plasma diminishes as the spores develop.

It would appear that the spores can only be liberated as the asci are exposed by the disintegration of the parenchymatous tissue. This occurs from above downwards in the open apothecia, but the stroma decays as a whole when the apothecia are not developed. In *M. Duriaei*, the parenchymatous tissue of the open apothecium gradually darkens from above downwards.

The spores (Plate II, figs. 15, 16, 17, 19) are muriform, with regular transverse septa, and longitudinal or oblique septa in some or all of the transverse loculi. At the lower end of the spore the septa are usually oblique. The longitudinal septa are often tardily developed, and hence in some cases the spores have been described as transversely septate only. Before septation, or before the formation of the longitudinal septa, the spores of *M. Duriaei* may be filled with close-set spherical globules. The wall of the spore is thin at first, but becomes thicker as the spore matures.

The colour of the ascospores is greenish hyaline. Brown ascospores have been observed in *M. Duriaei* and *M. Montagnei*, and in one instance in the former species an unopened ascus was seen, the wall of which, and the included spores, were brown.

It would appear that these had remained adherent to the decaying parenchymatous tissue of the disc of the apothecium, and had shared in the colour change of the parenchyma.

Since the foregoing account was written, Mr L. E. Miles has published a description of a new species of *Myriangium, M. tuberculans*, in *Mycologia*, XIV, pp. 77–80. His interpretation of the structure of the ascus of *Myriangium* differs from that outlined above, and may be quoted verbatim.

"Each locule is lined with a thick, hyaline sheath, inside which occurs a single ascus. When the stroma is crushed and examined under the microscope, this sheath easily separates from the tissue of the stroma and remains about the ascus, giving the appearance of being merely a very thick ascus wall. If the sheath becomes ruptured, however, the ascus immediately expands, chiefly in a longitudinal direction, often to two or two and one half times its original length, becoming oblong, broadly spindle-form, or ovate with blunt rounded ends, while the ruptured locule sheath collapses about its base. The ascus wall is quite thin as compared with this sheath, except at the apical end, where it is heavily thickened. There is no apical pore and the method of spore discharge has not been observed. Since the locules are indehiscent, and the pore at the apex of the ascus is absent, this probably is brought about by the irregular rupture of the ascus wall."

It will be seen that what I have regarded as the ascus is considered by Miles to be a sheath, while the hyaline plasma is regarded by him as the true ascus wall. In other words, *Myriangium* has ascigerous cells, each containing a single ascus which completely fills the cell. Against this view may be urged (1) the shape of the "ascigerous cell" in *M. Thwaitesii*, (2) the varying shapes assumed by the "ascus" on extrusion from the "ascigerous cell," and (3) the absence of an interior wall and the non-collapse of the "ascus" after the spores have escaped from it. It would appear, however, that the point can be definitely settled only by a study of the development of the structure in question.

Systematic.

As already indicated, species of *Myriangium* have been described as *Phymatosphaeria*, *Pyrenotheca*, and *Cenangium*. To these generic names von Höhnel has added *Diplotheca*. *Phymatosphaeria* Pass., *Pyrenotheca* Pat., and *Diplotheca* Starb. are now regarded as synonymous with *Myriangium* Mont. and Berk., though evidence as regards the first of these appears to be lacking.

The species now admitted as *Myriangium* by von Höhnel and others are as follows:

(1) Myriangium Duriaei Mont. & Berk., Lond. Journ. Bot. IV, p. 74. 1845.
(2) M. Montagnei Berk., loc. cit. supra.
(3) M. Curtisii Berk. & Mont., Ann. Sci. Nat., Sér. 3, XI, p. 245. 1849.
(4) Phymatosphaeria brasiliensis Speg., Fungi Puigg. p. 174. 1889.
(5) Myriangium dolichosporum Wilson, Proc. Roy. Soc. Victoria, V, p. 160. 1892.
(6) M. argentinum (Speg.) Sacc. & Syd., Syll. Fung. XVI, p. 800; Phymatosphaera argentina Speg., Fungi Argentini novi v. crit. p. 299. 1899.
(7) M. thallicolum Starb., Bih. K. Svensk. Vet.-Akad. Handl. XXV, p. 41. 1899.
(8) M. Pritzelianum P. Henn., F. Austral. Occid., Hedwigia, XL, p. 353. 1901.
(9) M. Acaciae McAlp., Proc. Linn. Soc. New South Wales, XXIX, p. 124. 1904.
(10) M. Bambusae Rick, Broteria, V, p. 39. 1906.
(11) M. Tunae (Spreng.) v. H., Fragmente, XIII Mitt. p. 78; Sphaeria Tunae Spreng., Vet. Akad. Handl. p. 49, 1820; Diplotheca Uleana P. Henn., Hedwigia, XXXVII, p. 205. 1898.
(12) M. Rhipsalidis (P. Henn.) v. H., Fragmente, VII Mitt. p. 60; Diplotheca Rhipsalidis P. Henn., Hedwigia, XXXVII, p. 206. 1898.
(13) M. floridanum (Ell. & Galw.) Rehm apud v. Höhnel, Fragmente, VI Mitt. p. 80. 1909.
(14) M. curreyoideum (Theiss.) Sacc. & Trott., Syll. Fung. XXII, p. 581; Phymatosphaeria curreyoidea Theiss., Beih. Bot. Centralb. XXVII, Abt. II, p. 402. 1910.
(15) M. philippinense Syd., Ann. Myc. XII, p. 567. 1914.

Of these, *M. Pritzelianum*, and, *fide* von Höhnel, *M. Tunae* and *M. Rhipsalidis* are known to be parasitic on plants. *M. Duriaei*, *M. Montagnei*, *M. Curtisii*, *Phymatosphaeria brasiliensis*, *M. dolichosporum*, *M. Acaciae*, and *M. philippinense* are parasitic on scale insects. Of the remainder nothing definite can be stated concerning the real host, but from the descriptions, *M. curreyoideum* would appear to be parasitic on plants, and *M. thallicolum* and *M. Bambusae* on scale insects. It would appear doubtful whether the two latter are distinct from *M. Duriaei*, but I have not seen specimens.

Von Höhnel instituted a family *Myriangiaceae* (Fragmente VI, p. 78), which he characterised as "Stroma superficial or erumpent, carbonaceous or brightly coloured, not perithecium-like, internally and externally of the same structure, with numerous loculi each containing one ascus." The characters of the genus *Myriangium*, according to von Höhnel, are "Stroma more or less carbonaceous, black; spores muriform, hyaline."

In the species parasitic on scale insects, the mycelium of the fungus permeates the body of the insect, and the stroma is formed over the insect or at the side of it on the host plant. In *M. Pritzelianum*, the mycelium permeates the plant tissues and grows out to form the stroma on the surface of the plant. In this latter species, the larger stromata are attached only in the centre of the base, or along a median line, but the smaller

stromata may be attached over the whole base and they may then appear to have the base embedded in the tissues of the host. In all cases, however, the actual stroma is formed externally. Montagne's description of *M. Duriaei* as erumpent may have been based on a specimen in which the scale insect was concealed in a crack in the cortex.

In none of the species examined by me can the stroma be said to be truly carbonaceous, as for example in the perithecia of *Rosellinia*, etc. The cortical layer is always evidently parenchymatous, and as a rule it is easily cut, though the stroma may break up under the knife, especially when old, because of the friability of the internal tissue.

In the available species parasitic on plants the stroma is merely parenchymatous. In those parasitic on scale insects the stroma is sclerotioid. In the latter case the shape of the hyphae in the young stroma recalls those of *Atichia*.

MYRIANGIUM.

Stroma superficial, parenchymatous or sclerotioid, usually black, simple, pulvinate, or compound and consisting of a basal disc bearing pulvinate, turbinate, or nail-shaped processes. Asci embedded singly in the parenchyma, in the processes when present, irregularly distributed or in more or less definite regions. Spores muriform, hyaline. Processes sometimes disintegrating at the apex, with the consequent formation of cup-shaped or convex apothecia.

Myriangium Duriaei Mont. and Berk., Hooker's *London Jour. Bot.* IV (1845), p. 73, "quoad specimina ex Pyr. Or. et Algeria." Stromata up to 5 mm. diameter, black or purple-black, shining, or dull and subpulverulent; base flattened-pulvinate, or flat and thin, lobed or continuous, generally radially plicate; apothecial tubercles pulvinate, flattened-pulvinate, or turbinate, up to 0·7 mm. high, usually crowded and concealing the base, rarely wanting; internally green, or greenish white, becoming purple or purple-black when old, friable. Open apothecia usually concave, up to 1 mm. diameter, with a narrow, incurved, incised margin, greenish black. Asci globose, 32–50 μ, or elliptical, 35–66 × 28–52 μ, the spores frequently confined to the lower end. Spores oblong-oval, or subfusoid, ends obtuse, straight or curved, usually with seven transverse septa, and one or more longitudinal or oblique septa in each loculus, constricted at the median septum, the upper half the broader, 14–37 × 6–15 μ, frequently with some globose spores, irregularly radially septate, 8–12 μ diameter. *Collema glomerulosum* Tayl., non Ach., in Mackay, *Fl. Hibern.* II, p. 108 (1836);

Cenangium asterinosporum Ell. and Ev., *Bull. Torrey Bot. Club*, x (1883), p. 76; *Pyrenotheca yunnanensis* Pat., *Bull. Soc. Bot. France*, Sér. II, viii (1886), p. 155; *Phymatosphaeria brasiliensis* Speg., *Fungi Puigg.* p. 174 (1889); *Phymatosphaeria argentina* Speg., *Fungi Argentini novi v. crit.* p. 299 (1899); *Myriangium floridanum* (Ell. and Galw.) Rehm apud v. Höhnel, *Fragmente zur Myk.* vi, p. 80 (1909); *Myriangium philippinense* Syd., *Ann. Myc.* xii (1914), p. 567.

In the original description, specimens were cited from France, Algeria, and Australia. The type specimen is consequently that from France, and this was regarded as the type by Montagne. The specimen from Australia is a different species, and is, in fact, identical with *M. Montagnei* Berk. Up to the present, there is no evidence that *M. Duriaei* occurs in the Australian region. The type in Herb. Montagne from Pyrénées Orientales, dated 1829, contains an abundance of specimens; it is the form usually found in temperate climates.

In Mackay, *Flora Hibernica*, ii, p. 108, Taylor recorded this species for Ireland under the erroneous identification *Collema glomerulosum* Ach. He cited specimens from Roughty. Herb. British Museum has Irish specimens marked "On ash, Roughty, Kerry" (with scale insect); "Fl. Hib. Dr Taylor," not localised; "Dunkerrin"; "Carrigaline, Cork, Oct. 1858, J. Wright"; and "Carrigaline river, Cork, 1865, J. C." (with scale); these have not been re-examined microscopically. Herb. Kew has a specimen from Taylor, "on ash trees near Dunkerrin"; this is *M. Duriaei*, but is apparently immature.

British specimens are represented in Herb. Kew by Crombie, *Lich. Brit. Exsicc.*, No. 8; and Herb. British Museum has the same Crombie number, marked "near Penzance, Cornwall, Wm. Curnow"; this has asci globose 48 μ diameter, or elliptic, 46–56 × 36–40 μ, and spores 24–36 × 9–13 μ. Another specimen, in Herb. B. M., is marked "Bene fertiles. On the branches of ash trees, St Levan, Penzance, legit W. Curnow, v, 1874," and includes a scale insect with *Microcera coccophila*; its asci are globose, 32–38 μ, or elliptic, 36–42 × 28–34 μ, with spores, not fully mature, 16–28 × 9–11 μ. A number of other British specimens in Herb. B. M. have not been re-examined microscopically; these include the following: "Trevella Wood, Penzance, W. C. leg. 1864"; scale and *Microcera* present. "Trevella Carne Grove, Penzance, March 28, 1865, W. Curnow." "Treventh Farm, Penzance, W. Curnow leg. 1870." "Castle Hornock, Penzance, Feb. 1870 and Jan. 1871. W. Curnow." "Ash bark. Treveneth near Penzance, Cornwall, March 7, 1871. W. Curnow"; scale present. "On ash in Trevella Wood, Penzance, Dec. 10, 1873. W. Curnow"; scale and *Microcera* present.

"Trevella Carne Grove, Penzance, 1886, *duce* W. Curnow"; scale present. "Ash trees, Trengwainton, Penzance." "Near Penzance"; scale present. "Penzance, ex herb. W. Curnow." "Ash trees, Penzance, H. B. H." "On ash, wood near the Abbey farm." "Ilsham Walk, Torquay, J. M. C." "Ash trees, Shanklin, I. W."; scale present. "Near Ryde, Isle of Wight, A. B."; scale and *Microcera* present. "Brading, I.W. Leg. 1868." "On trunks of trees, Shanklin, Isle of Wight, legit J. M. C., IV, 1873"; scale present. "Cook's Castle, near Shanklin, I.W., H. Piggot." "Danny, W. Mitten" [Danny Park, West Sussex].

During the Autumn Fungus Foray of the British Mycological Society, 1920, specimens were collected in abundance on *Chionaspis salicis* on ash, Horner Woods, near Minehead, Somerset. The record of effete stromata of *M. Duriaei* for Norfolk and Yorkshire in *Trans. British Mycological Society*, 1920, vol. VII, p. 33, proves on further examination of the specimens to have been a mistake.

M. Duriaei in England, as far as the records show, occurs chiefly in the South-Western Counties from Cornwall to the Isle of Wight, and has been found as far east as Sussex. Its distribution coincides with that of *Microcera coccophila* in England, and, like the latter, it has been found only on *Chionaspis salicis*.

Of French specimens, Herb. Kew has one collected by Roussel, "ad ramos excelsos Ulmi, Meloduno [= Melun, near Paris], March 1850," which includes a scale insect. Herb. B. M. has other examples from the same locality, dated March 8th, 1853, and June 4th, 1855. The asci are globose, 40–50 μ, or elliptic, 48–64 × 40–52 μ, and the spores are generally large, 20–30 × 9–14 μ. There are also in Herb. B.M., "C. Roumeguère, Lichens d'Europe, *Myriangium Duriaei* Berk. & Mont., Carcassonne—Aude. Ad ramos excelsos Ulmi, 1869"; "*Myriangium Duriaei* Mont. & Berk. Sur les Frênes à la Mothe St. Heraie, Deux-Sèvres, Richard, 1873," with a scale insect; "*Myriangium Duriaei* Mont. and Berk., sur un jeune Érable entre Valboum et la tour de Marram (?) (Pyr. Or.), Juillet, 1872, Weddell"; "Desmazières 1948," scale present; and "Desmazières 1598, Éd. II, Sér. I."

Italian specimens in Herb. Kew are "Rabenhorst, Lichenes Europaei 635. Ad truncos Lauri a Boboli Florentiae, Jun. 1861, leg. L. Caldesi," scale and *Microcera* present; "Massalongo, Lichenes Exsicc. Italiae, No. 27," scale present; "Trevisan, Lichenotheca Veneta, Ser. I, Fasc. IV (appendix), No. 146. Ad cort. Fraxini Orni circa Bassano, Marostica, Valdagno in prov. Vicetina," scale present. Herb. B.M. has the first of these, and also "Erbar. Critt. Ital. 745. Sull' alloro nel giardino di Boboli a Firenze," which includes a scale insect and *Microcera*. Raben-

horst 635 has asci globose 40 μ, or elliptic 36–56 × 32–36 μ, and spores 15–36 × 8–15 μ; the surface of the stroma is pulverulent, and the open apothecia are up to 0·9 mm. diameter. The specimen in Massalongo 27 examined contained only immature asci, and Trevisan 146 was apparently also immature.

"Maire, Mycotheca Boreali-Africana, No. 45. Sur les troncs de *Laurus nobilis* L. attaqués par le Coccide *Aonidia Lauri* Bouche, Bouzarea près Alger, 28. 2. 1912" is represented in Herb. Kew; the specimen, which is accompanied by a scale insect, bears stromata which are purple-brown or purple-black internally and are therefore old, but apparently they do not contain asci.

Passerini in *Nuovo Giorn. Bot. Ital.* VII, p. 188 (1875), described a fungus from Abyssinia as *Phymatosphaera abyssinica*. Passerini's species has since been regarded as *Myriangium Duriaei* (cf. Ellis and Everhart, Rehm, von Höhnel), but I have not been able to trace any account of a re-examination of the type specimen. His description does not agree with *M. Duriaei* in several details. He stated that the stroma contained spermatia as well as asci, and that the spores measured 10–15 × 3–4 μ. This measurement is smaller than any I have met with in *M. Duriaei*.

Herb. British Museum contains "Rabenhorst-Winter-Pazschke, 4067, *Myriangium Durieui*. Ad corticem Gleditschiae triacanthis, Amer. bor., Fountain Bluff, Jackson County, Ill. May 1894, leg. C. H. Demetrio"; "Ellis and Everhart, Fungi Columbiani, by G. Bartholomew, 1941, *Myriangium Durieui* Mont. and Berk., on *Crataegus*, London, Canada, Nov. 7, 1903, E. Dearness"; "Lichenes Exsiccati, G. K. Merrill, 174, *Myriangium Duriaei* (Mont. and Berk.) Tuck., Sanford, Florida, S. Rapp, 1910," scale present; "143, Decades of N. A. Lichens, prepared by Clara E. Cummings and A. B. Seymour. *Myriangium Duriaei* (Mont. and Berk.) Tuck., on *Nyssa multiflora*, Acto, N. J., Sept. 27, 1893, coll. Prof. H. A. Green," scale present; all of which appear to be correctly named.

In Herb. Kew, one of Curtis's specimens which was not named by Berkeley, No. 218 on *Crataegus Crus-galli*, North Carolina, is *M. Duriaei*, but I was unable to trace the other Curtis's numbers against which Berkeley placed "Collemal" in the MS. list. The Ravenal specimens assigned to *M. Curtisii* in Herb. Kew, viz. "Fungi Americani Exsiccati 332, in cortice *Nyssa*, Aiken, S. C.," and another specimen on the same host from the same locality, are *M. Duriaei*.

Ellis and Everhart in 1883 described *Cenangium asterinosporum*, collected on living branches of *Vaccinium corymbosum*, Newfield, N.J., April 1883. Subsequently, in *North American*

Pyrenomycetes (1892), they referred their fungus to *Myriangium Duriaei*. Specimens, which are accompanied by a scale insect, were issued in Ellis, *North American Fungi*, 1279, of which there are two copies in Herb. Kew. The stromata are greenish internally, with a stout black cortex, 0·1 mm. thick. The asci are globose, 26–32 μ, or oval or pyriform, 32–38 × 20–26 μ. The spores are those of *M. Duriaei*, but small, 16–19 × 7 μ, with some spherical 8 μ diameter. It is undoubtedly *M. Duriaei*. The stromata are on scales which are embedded beneath the outer layers of the bark; hence Ellis and Everhart described the fungus as erumpent.

Through the kindness of Prof. H. S. Fawcett, I have specimens of *M. Duriaei* from Florida on a scale on *Citrus*. These are flat, covered with close-set, pulvinate elevations up to 0·4 mm. diameter. The surface is pulverulent and there is no free margin. The asci are globose, 32–40 μ, or elliptic, 36–48 × 28–32 μ, and the spores measure 14–28 × 8–13 μ. Many spherical spores, 9–10 μ diameter, are present, one ascus having six of its eight spores spherical. Professor Thaxter has kindly sent me two gatherings from West Palm Beach, Florida, in which the stromata are either flattened-pulvinate with nearly sessile apothecia, or have well-developed turbinate apothecia.

Myriangium floridanum (Ell. and Galw.) Rehm was described by von Höhnel from a specimen on *Citrus* from Florida in Herb. Rehm *ex* Herb. Ellis, labelled *Southworthia floridana* Ell. and Galw. The latter name was not published. Professor Thaxter, who has kindly interested himself in the elucidation of this, informs me that there does not appear to be any specimen labelled *Southworthia* in the Ellis Herbarium, but that there is one marked "*M. Duriaei*, on orange, Florida, Miss Southworth," which may be the specimen in question. From his own herbarium Professor Thaxter has sent me a specimen on orange from Florida, which he received from Ellis as *Phymatosphaeria Southworthii* Ell. and Galw.; the latter is the flat form of *Myriangium Duriaei*, with depressed pulvinate tubercles up to 0·8 mm. diam. and 0·5 mm. thick, asci oval, 50–56 × 40–42 μ, or globose, 40–44 μ diam., and spores, 24–32 × 10–14 μ. It would appear probable that all these names refer to the same collection, and that Ellis removed the *Southworthia* label from his herbarium specimen.

Dr C. Spegazzini has kindly submitted his herbarium specimens of *Myriangium* for examination. *Phymatosphaeria brasiliensis* is represented by three collections; 1678 Puiggar., containing flat specimens, with plane apothecia, up to 1 mm. diameter, crowded in patches up to 5 mm.; F. Puigg., No. 333, on branches of orange, La Plata, March 26th, 1889, containing

pulvinate or flattened stromata parasitic on *Lepidosaphes*; 3789, July 20th, 1883, on bark of Laurineae, containing flat specimens; all these are *Myriangium Duriaei*. *Phymatosphaeria argentina*, La Plata, May 1906, contains small flat specimens, again *Myriangium Duriaei*, together with immature *Nectria* (? *Sphaerostilbe*). I was unable to find *Myriangium* stromata in the type of *M. andinum*, Myc. Argent. VI, *An. Mus. Nac. Hist. Nat. Buenos Aires*, XXIII, p. 99 (1912).

Lindig made three gatherings of *Myriangium* in Colombia (Nova Granata), two of which, Nos. 2669 and 2789, were issued as *M. Duriaei*, and the third, No. 2583, as *M. Curtisii*. There are specimens of the three numbers in Herb. Kew, but they are all the same species, viz. *M. Duriaei*. Consequently Millardet's figures all refer to one species. The spores in 2583 measure 16–25 × 7–9 μ; in 2669, 22–37 × 10–13 μ; and in 2789, 22–32 × 9–13 μ. From Professor Thaxter, I have specimens of *M. Duriaei* from Corral, Chili, Dec. 1905.

Specimens of *Myriangium* from Asia are unaccountably absent from British herbaria, the only ones found being an unnamed Ceylon specimen in Herb. Kew sent by Thwaites, and the specimen of *M. Duriaei* from Java distributed by von Höhnel. The latter is parasitised by *Sirosphaera botryosa* Syd.

Patouillard in 1886 described a fungus from Yunnan as *Pyrenotheca yunnanensis*. This was subsequently referred by Ellis and Everhart (?) to *Myriangium Duriaei*. The type in Herb. Paris is scanty, but on macroscopic examination it appears to be *M. Duriaei*, and Dr Patouillard informed me that he thought that the reference was correct.

Several collections of this species have been made in Ceylon. Parkin (p. 33) recorded it on *Chionaspis biclavis* on *Tabernaemontana*, and on *Aspidiotus camelliae* on *Osbeckia*; the former specimens have flat stromata, with slightly elevated processes, and have developed at one side of, or round the scale; the asci are generally elliptic, 40–54 × 32–42 μ, sometimes globose, 34 μ; the spores measure 16–30 × 8–12 μ, with many spherical, or nearly spherical, 12 μ diameter. Other specimens are as follows: on *Aspidiotus aurantii* on mulberry, Peradeniya, August 1907, May 1909, August 1919; on *Chionaspis* (?) on *Thespesia*, Peradeniya, July 1913; on *Chionaspis* on *Gardenia florida*, Peradeniya, November 1921; on *Pithecolobium subcoriaceum* Thw., Hakgala, March 1922.

From Mauritius, I have a specimen on *Aspidiotus* on bamboo, Oct. 9, 1919, which is immature but appears to be *Myriangium Duriaei*.

Myriangium philippinense Syd. (Plate II, fig. 5) was described by Sydow from specimens on leaves of *Eugenia perpallida*, Prov.

Bulucan. I have examined the part of this gathering retained by the Bureau of Science, Manila, S. 259. The fungus occurs with *Microcera Merrillii* Syd., both of them on a scale insect. Only one stroma of the *Myriangium* was present. This overgrew the scale, and consisted of a flat, very thin disc, irregularly circular, 1·2 mm. diameter, continuous, slightly concentrically ridged, which bore in the centre three close-set, pulvinate processes, 0·2–0·3 mm. diameter and 0·2 mm. high. The stroma was black, with a dull surface, and the basal disc was only 20 μ thick. In section the tubercles were greenish black, with a distinct green colour by transmitted light. The specimen was unfortunately immature, and did not contain any asci. The structure, however, is that of *Myriangium Duriaei*, and in general shape it approaches the thin forms observed in gatherings from Ceylon, Florida, and Colombia. Sydow stated that the spores are ovato-oblong, rounded at the ends, with three transverse septa, and longitudinal septa in one to three loculi, 18–24 × 6–8 μ, the upper half generally the broader. The shape and size of the spore agree with *M. Duriaei*, the only difference being the small number of transverse septa, which may be due to immaturity, though the fact that longitudinal septa were present is opposed to that.

Another specimen of *M. Duriaei* from the Philippines was forwarded to me by Mr E. E. Green, on *Mytilaspis* and *Aspidiotus aurantii* on *Hippocratea* sp., coll. C. S. Banks. It is the usual tropical form.

There is considerable variation in the shape and appearance of the stroma in this species. In British examples the surface of the stroma is usually shining, and young specimens have been collected in Ceylon in the same condition. But, in general, the surface of the stroma in tropical examples, and full-grown specimens from subtropical countries is dull and matt, or pulverulent.

The basal stroma is usually pulvinate or flattened-pulvinate. In some Ceylon specimens, however, it forms a thin flat disc, not exceeding 0·1 mm. in thickness, and similar specimens occur in Lindig 2669 and in collections from Florida. It may be lobed and radially plicate, but in the thinner forms it is generally continuous. In the specimens from Horner Woods, Somerset, many of the stromata consist of a central boss, overgrowing the scale, from which radiate three plicate lobes, but this form is not universal throughout that collection. The outer layer of the stroma and the apothecial processes forms a black wall, usually thin, but sometimes attaining a breadth of 0·1 mm., as in Curtis 218. This greater development of the black cortex was noted by Millardet in Lindig 2583

The apothecial processes (Plate III, fig. 1) in temperate examples are usually turbinate when full-grown, and they then weather at the apex into a concave disc, the open apothecium. As a rule, the mature asci, in such examples, occur only in the open apothecia. In examples from the tropics, the apothecial processes may be pulvinate or flattened-pulvinate, and they contain mature asci before the apical layer has weathered off. Indeed, gatherings from the tropics, as a rule, do not bear any open apothecia, although the spores are mature. In one example from Ceylon, the basal stroma was 0·075–0·1 mm. thick, and the apothecial processes 0·1 mm. high, giving a total thickness not exceeding 0·2 mm.; the asci in the closed processes were nevertheless mature. Again, Lindig 2669 contains similar mature stromata, the total thickness of which is only 0·25 mm. Despite the extreme variation in the shape of the stromata in the different collections cited, it has not been found possible to separate them into different species. In all essential characters, spores, asci, internal colour and structure, they are *M. Duriaei*.

What is believed to be an abnormal form of this species has been collected at Hakgala, Ceylon, on *Lepidosaphes* on *Cinnamomum ovalifolium*. The stromata are up to 2 mm. diameter, more or less circular, up to 0·5 mm. thick, tuberculate, consisting of clusters of tubercles up to 0·5 mm. diameter. At first they are white, and gradually turn black. Most of the stromata are immature, but in some cases the tubercles are crowned with pezizoid discs, 0·5 mm. diameter. Internally the immature stromata are white, with a narrow black peripheral zone. There is a well-defined cortical palisade layer, 24 μ deep, and the interior of the stroma is composed of thick-walled branching hyphae, 3 μ diameter, in segments about 16 μ long, or in spore-like oval joints, 6 × 2 μ. The mature apothecia are darker internally and may show a greenish tinge. The asci are globose, 28–32 μ, or oval, 36–40 × 28–32 μ, and the spores, 18–24 × 8–10 μ. The spores, asci, and the structure of the stroma are exactly those of *M. Duriaei*; and the specimens appear to be a form of *M. Duriaei*, lacking the green colouring matter.

Distribution. Europe—England, Ireland, France, Italy. Africa—Algiers, Mauritius. Asia—Ceylon, Java, Yunnan, Philippines. North America—United States, Canada. South America—Colombia, Chili, Brazil, Argentina. Generally distributed throughout the tropics and extending into the temperate zones, but not yet known from Australia.

Myriangium Curtisii Berk. & Mont., *Ann. Sci. Nat.*, Sér. 3, XI (1849), p. 245. Stromata pulvinate or flattened-pulvinate, up to 8 mm. long, 5 mm. wide, 2·5 mm. high, sometimes crowded

together in large masses, usually with an abrupt sloping margin, rarely with a thin flat margin, surface plicate, margin radially plicate, black, internally pale brown or yellowish brown or almost white, friable. Apothecial tubercles flattened-pulvinate, about 0·2 mm. high, or subturbinate, up to 0·8 mm. high. Apothecia usually sessile on a broad base, occasionally constricted below into a narrow, stalk-like base, up to 2 mm. diameter, black, flat, becoming convex and dark grey with a brownish white zone near the margin. Asci in the open apothecia confined to a zone parallel to the upper surface, globose, 26–28 μ diameter, or elliptic, 32–44 × 21–34 μ. Spores oblong-oval, narrow-oval, or subfusoid, straight or curved, with up to seven transverse septa, constricted at the median septum, and longitudinal or oblique septa in some or all the loculi, 12–28 × 5–11 μ. *Myriangium tuberculans* Miles, Mycologia, XIV, p. 80 (1922).

This species was founded on a specimen collected by Curtis in South Carolina. Berkeley sent Curtis's specimen to Montagne, but apparently he did not keep a duplicate, and there is no Curtis specimen in Herb. Kew labelled *Myriangium Curtisii*. Reference to Curtis's MS. list shows that he sent numerous specimens which Berkeley noted in the list as "Collemal" only, but unfortunately Montagne did not cite Curtis's number, and none of these specimens now available in Herb. Kew is referable to *M. Curtisii*.

In Herb. Kew, under *Myriangium Curtisii*, there are three specimens. One of these is Lindig 2583, Nova Granata, which is *M. Duriaei*. Another is marked "*Myriangium Curtisii* B. on *Nyssa*. Aiken, S. C. Will try to get more of this. H. W. R.," all in Ravenel's handwriting; it has large stromata, up to 5 × 4 mm. in plan, slightly elevated apothecia, and greenish internal tissue; it is immature, but appears to be *M. Duriaei*. The third specimen is "H. W. Ravenel. Fungi Americani Exsiccati 332; *Myriangium Curtisii* Berk., in cortice *Nyssa*. Aiken, S. C."; it contains specimens on bark in bad condition and indeterminable, and a twig bearing stromata which match the previous Ravenel specimen, immature, but apparently *M. Duriaei*. Thus there does not appear to be any specimen of *M. Curtisii* in Herb. Kew.

In Herb. Montagne, there is a specimen marked "*Myriangium Curtisii* Berk. and Mont." in Broome's handwriting, with "Mont., Ann. Ser. 3, t. 12, 1849" added by Montagne, and another, apparently part of the same gathering as the foregoing, marked by Berkeley "*Myriangium Curtisii* Berk. and Mont. Car. Inf.," and by Roussel "ex clar. Berkeley, 1853," both of which appear to be *M. Duriaei*. There are also an American specimen from Sprague, which is *M. Duriaei*, and Lindig 2583

already referred to. In addition to these, there is a specimen marked by Montagne, "*Myriangium Curtisii* Berk. and Mont. Car. Inf. Amer. Boreal.," which is enclosed in a piece of paper bearing the inscription, "*Myriangium.* The best specimen" by Curtis; this has the large apothecia of *Myriangium Curtisii*, and is probably the type. Another specimen "1442 Car. Inf." appears to be part of the same collection as the foregoing, but is labelled by Montagne, "Myriangium Berkeleyi Montag. *Myriangium Curtisii* Berk. and Mont., Car. Super. [*sic*], cl. Berkeley."

It will be evident that the old herbarium specimens are somewhat confusing; and it is not surprising that later workers have regarded *M. Curtisii* as identical with *M. Duriaei*, since most of the herbarium specimens which are labelled *M. Curtisii* are *M. Duriaei*. Even Montagne's herbarium shares this confusion, though had it been consulted it would have been seen that there were two species. The best example of *M. Curtisii*, however, is in Herb. British Museum *ex* Herb. Phillips. It is labelled by Curtis, "*Myriangium Curtisii* B. & M. ad Styracem, fine specimens," and by Phillips, "*ex* Herb. Berkeley." On a mere casual glance, one is impressed by the size and shape of the apothecia.

This specimen on *Styrax* has large black stromata, which have a plicate surface and usually an abruptly sloping margin. The apothecia are sessile, *i.e.* attached over a broad base, or subturbinate, up to 0·8 mm. high; the smaller have a black upper surface, but the larger are dark grey with a brownish white margin, and up to 2 mm. in diameter. The internal tissue is brown, though there is a distinct green tinge in thin sections of young stromata, and at the base of the old stromata under a high magnification by transmitted light. The asci are confined to a narrow zone parallel to the upper surface. The specimens are accompanied by a scale insect.

Another gathering of this species was made by Professor Thaxter at Tyler City, Conn., Oct. 1888, on *Amelanchier*. In this the stromata are usually flat, rarely pulvinate, and some have a narrow, flat, plicate margin. Internally they are yellow-brown with a thick black cortex. The apothecia are close-set, up to 1·5 mm. broad, but they are black, and do not stand out prominently like those of the previous specimen; some of them are nail-shaped, *i.e.* contracted below into a narrow, stalk-like base. The spores in this gathering measure 20–24 × 8–9 μ.

The stroma of *M. Curtisii* differs from that of *M. Duriaei* in its internal colour. In this respect it resembles *M. Montagnei*, and it is closer to the latter species in the shape of the apothecia and the arrangement of the ascigerous layer than it is to *M. Duriaei*. Its spores, however, resemble those of *M. Duriaei*.

M. Montagnei differs in the shape of its spores and the consistency of the stroma.

In the available specimens, the asci and spores are smaller than those of *M. Duriaei*.

In Herb. Kew, there is a sheet marked by Massee, "*Myriangium Berkeleyi* Mass. ined." It bears two collections. One of these is marked in Cooke's handwriting, "*Myriangium* sp., on living bark of *Acacia horrida*, Cape, Kalch."; there is a black scale insect present, but nothing of the fungus remains. It may be noted that Kalchbrenner's specimens of *Microcera* were on an insect on *Acacia horrida*. The other collection is marked "*Ex* herb. Berkeley P." in an undetermined handwriting, and "*Myriangium*" by Berkeley: a drawing by Massee shows spherical asci with one-septate spores, marked "brown when mature." There is no scale insect on the latter. This second specimen is obviously not *Myriangium*, and neither is in a fit condition for determination. *M. Berkeleyi* Mass. has no relation to *M. Berkeleyi* Mont., which was apparently the name suggested by Montagne for *M. Curtisii*.

Miles has recently described *M. tuberculans*, found on *Careya illinoensis*, at Ocean Springs, Mississippi. From specimens with which he has kindly furnished me, this is *M. Curtisii*. The apothecia in the larger specimens are convex, so that the surface is facetted. The tissue is more compact than in the old herbarium specimens, and the stroma consequently less friable, again approaching *M. Montagnei*. The spores are 18–28 × 10–12 μ, rather larger than in the other available specimens, in which they do not exceed 24 × 9 μ. The specimens are accompanied by *Microcera coccophila*, the synnemata of the latter arising at the side of, or beneath, the *Myriangium*.

Distribution. North America.

Myriangium Montagnei Berk., Hooker's *London Journal of Botany*, IV (1845), p. 74. Stromata up to 5 mm. diameter, pulvinate or flattened-pulvinate, tuberculate at first, without any free margin, dark brown, appearing tomentose, becoming black and more or less shining, internally pale brown or rufous at first, becoming blackish brown when old; substance cheesy, not friable. Tubercles at first flattened-pulvinate, sessile, rarely forming obconic processes up to 1 mm. high. Apothecia discoid, with a stout rounded black margin and a sunken black or brown disc, up to 1 mm. diameter; or concave, with a narrow black margin and a rufous or pale brown disc, up to 2·5 mm. diameter; or convex, without a differentiated margin, brown or mottled, up to 2·5 mm. diameter. Asci globose, 42–65 μ diameter, or elliptical, 42–64 × 40–54 μ, exceptionally 80 × 48 μ. Spores

oval, narrow-oval, or subcymbiform, straight or curved, ends obtuse, with 6 to 8 transverse septa (usually 7), slightly or not constricted at the median septum, vertical septa tardily developed, 18–40 × 6–15 μ. *Myriangium Duriaei* Mont. and Berk. (*loc. cit.*), quoad spec. ex Swan River, Australia; *Myriangium Duriaei* Knight, *New Zealand Institute Transactions and Proceedings*, XVI (1883), p. 400; *Myriangium dolichosporum* Wilson, *Proc. Roy. Soc. Victoria*, V, p. 160 (1892); *Myriangium Acaciae* McAlpine, *Proc. Linn. Soc. New South Wales*, XXIX (1904), p. 124.

The appearance of the fungus differs greatly according to the degree of development of the apothecia. In the commoner form, judging from the available specimens, the stroma is black and the apothecia are sessile with a stout, rounded, black rim (Plate II, fig. 9). But when the apothecia have opened widely and have a convex surface, the edges of adjacent apothecia meet, so that the stroma becomes uniformly convex; and in these cases the colour is usually rufous brown or pale brown, sometimes mottled with yellow-brown. The difference in the colour of the stromata is due to the weathering or disintegration of the outer layers, and in this there are two effects, (1) removal by weathering of the outer brown tomentose or granular coat which leaves the whole stroma black, and (2) the disintegration of the upper surface of the apothecial tubercles, which exposes the inner tissues and so causes the open apothecia to be pale brown or blackish brown according to the colour of the interior. The extreme forms are so different that it was at first thought that they were two distinct species. But they occur together in several gatherings, and in one (Cheel, No. 47) both forms of the apothecium occur on the same stroma.

In general, the apothecia are sessile and the open apothecia are attached over a wide base. In rare cases they are stalked, and the open apothecia may then be nail-shaped, as may occur in *M. Curtisii*. In the unopened apothecium, the asci occupy a lenticular zone which is horizontally narrow-elliptic in longitudinal section (Plate III, fig. 7), as figured by Knight; if the interior of the stroma has become blackish, this zone retains a yellow-brown colour. In the widely-open apothecia, the asci occupy a narrow zone parallel to the surface (as in *M. Curtisii*), and this may be darker than the context, probably owing to atmospheric action (Plate III, figs. 5, 6).

The immature spores are narrower than the mature spores. The longitudinal septa are tardily developed, and the transverse septa are always the more distinct. There is a marked difference in the size of the spores in the available collections, but it has not been possible to associate this difference with any other character.

In the type of *M. Montagnei* in Herb. Kew (Drummond, No. 262), there are two specimens. One, consisting of a piece of wood, bears thin, dark brown, flat stromata, 2 × 0·75 mm. in plan, tomentose, slightly tuberculate, sometimes radially striate or ridged; this appears to be immature. The other, on a twig, is flat, with polygonal, close-set, slightly elevated, flat-topped tubercles, 0·7 mm. diameter; some specimens are purple-brown, others black and more or less shining; they are pale brown internally; this again appears to be immature. There is also in Herb. Kew, a drawing marked "*Myriangium Montagnei* Berk.," with descriptions in French (? by Montagne), which shows the spores either muriform or transversely septate. The drawing bears the number 380, which is presumably the magnification; if so, the spores are 18–20 × 5–8 μ. Montagne's specimen in Herb. Paris is very poor, but, as far as external appearance goes, is the same as that in Herb. Kew.

Another specimen collected by Drummond in the same locality (Swan River) was assigned by Berkeley (*loc. cit.*) to *M. Duriaei*. This, in Herb. Kew, has blackish brown stromata, pulvinate, up to 4 mm. diameter, yellow-brown internally; the apothecia are large, sessile, up to 2·5 mm. diameter, yellow-brown, with a narrow, blackish, incurved and plicate margin. The asci are globose, 42 μ diameter, or elliptic, 42–52 × 40 μ, and the spores, 24–30 × 7–10 μ, sometimes with only transverse septa. Its appearance is different from that of the specimens assigned to *M. Montagnei*, but on the evidence of the further specimens now available it is the same species. It is associated with a scale insect.

Dr C. Knight described this species in a paper "On the Lichenographia of New Zealand" (*loc. cit.*) under the erroneous identification, *Myriangium Duriaei*. His figures show the typical unopened apothecial process (Plate III, fig. 7), and spores only transversely septate, obviously from immature specimens. He stated that the apothecium had a thick margin, that the "hymenium" was yellow-brown, and the spores, 20 × 7·5 μ, usually three-septate. There are specimens from him in Herb. Kew, received November 1883, which have apothecia with a stout rounded margin, but are immature; they are accompanied by a scale insect.

M. dolichosporum was described by Wilson from specimens on twigs of *Hymenanthera Banksii*, Maffra, Victoria, March 1889. There are specimens of this collection in Herb. Kew, No. 1081, Nat. Herb. N.S.W., Bot. Gardens, Sydney, which are associated with a scale insect (? *Aspidiotus*). In some examples the apothecia are almost sessile, but in others they are obconic, and up to 1 mm. high. Wilson described the spores as cylindrical,

simple or obsoletely septate, arcuate, somewhat acuminate at the apices, with minute guttae arranged in the longitudinal axis, 40 × 6 μ, evidently from immature specimens. He noted that the stroma does not swell when immersed in water, and stated that it contained granular gonima, usually conglomerate, 2–7 μ diameter. The specimens agree with *M. Montagnei* in all essential details, but are exceptional in their elongated apothecial processes.

Other collections of this species by the Rev. F. R. M. Wilson are included in Herb. Kew under *Myriangium Duriaei*, viz. No. 1082 Nat. Herb. N.S.W., Olinda Creek, Lilydale, Victoria, Feb. 28th, 1898; No. 1082, Nat. Herb., N.S.W., St Crispin's Well, Mount Wellington, Tasmania (no date); and (without number) Red Bluff Victoria, May 2nd, 1893. The spores in the second of these are 22–30 × 7 μ, some muriform, others transversely septate only. All three are associated with scale insects.

No. 47, E. Cheel, Sydney, on branches of *Casuarina distyla*, Centennial Park, May 13th, 1901, is included in Herb. Kew as *Myriangium dolichosporum affine*. Its apothecia vary from discoid, with a stout black margin, to widely-open without differentiated margin. Its spores are 18–24 × 6–8 μ, and it does not differ in any respect from *M. Montagnei*. This gathering is associated with a scale insect.

The type of *Myriangium Acaciae* McAlp. was collected on *Acacia dealbata* at Plenty River, Victoria. I have not seen that specimen, but Mr C. C. Brittlebank has kindly forwarded me one on *Acacia longifolia*, collected in 1907. It is associated with a scale insect. The gathering includes black, more or less shining stromata with discoid apothecia, and brown tomentose stromata with widely-open convex apothecia. In one apothecium the spores measured 28–40 × 13–15 μ, while in another they were 24–28 × 8–12 μ. McAlpine gave the spore measurement 30–38 × 11–13 μ, rarely 42 μ long.

M. Montagnei has been found in Victoria, New South Wales, West Australia, Tasmania, and New Zealand. It would appear to be the common species on scale insects in the Australian region, the records of *M. Duriaei* being, as far as they can be tested, incorrect. It has not been recorded from any other country. I have, however, a specimen of a *Myriangium* on *Chionaspis Manni* Green, on tea, from Darjeeling, India, which I would provisionally refer to this species. The stroma is pulvinate, about 2 mm. diameter and 0·4 mm. high, covered with close-set rounded tubercles which sometimes are produced into short clavate processes: internally it is brown, and of the same consistency as *Myriangium Montagnei*. Unfortunately the specimen is immature and does not contain any asci.

Distribution. Australia, New Zealand, Tasmania.

Myriangium Thwaitesii Petch, n. sp. Stromata circular, flattened-pulvinate, about 2 mm. diameter, black, rugose, generally umbilicate in the centre at first; apothecial processes little elevated, 0·4–0·6 mm. diameter, turbinate or nail-shaped, flat-topped, first produced at the edge of the stroma more or less in a ring, internally white or brownish white. Asci at first narrow-clavate, usually becoming pyriform with a distinct foot, 52–64 × 22–30 μ, sometimes oval, 45 × 20 μ, parallel to one another in a single row, forming a peripheral ascigerous zone at the apex of the apothecial process: ascus wall 2–4 μ thick, attenuated towards the foot; spores cymbiform, 23–28 × 8–13 μ, usually transversely seven-septate, with three transverse septa in each half, and longitudinal septa in all but the terminal loculi, frequently with oblique septa in the upper loculus, ends subacute, not notably constricted at the septa.

This species was collected by Thwaites, the specimens in Herb. Kew and Herb. Peradeniya being marked South of the Island, July 1868. The specimen in Herb. Kew was marked *Myriangium* by Berkeley, but it was not referred to in the *Fungi of Ceylon*. Subsequently it was included under *M. Duriaei* in Herb. Kew.

In section the stroma is almost white, with a black or black-brown zone at the periphery. When mounted, a slight brown coloration is seen between the cells in some parts of the section, while in others this is absent. The intercellular substance, however, is present throughout the stroma, as may be determined by staining. With chlor-zinc iodide this substance stains yellow-brown, while with eosin it becomes pink. Consequently it is only the green or brown colouring matter which is lacking, as compared with other species. Towards the exterior, this substance becomes blackish brown, and at the exterior black.

The cells of the stroma, in the available specimens, are nearly all oval or globose, and solid or thick-walled, 5–14 × 5–10 μ. Elongated cells are rare and occur chiefly in the neighbourhood of the asci; these may be rectangular or cylindric, up to 20 × 5 μ. Owing to the deficiency of colouring matter and the obliteration of the cell lumina, the stroma is not obviously parenchymatous in unstained sections, the tissue in the uncoloured parts appearing as if in continuous sheets. The cortical layer is composed of cells of the same shape as the body of the stroma; there is no palisade layer.

This species differs from all the others described here in the shape of its asci and spores, and in the structure of the stroma. As the asci are in a single layer, it would be placed in the *Saccardiaceae*, not in *Myriangiaceae*, on Theissen and Sydow's classification (*Ann. Myc.* XV, p. 441).

In the type specimen, the fungus is parasitic on a scale insect on the stem of an undetermined tree.

Distribution. Ceylon.

The microtome sections and photographs have been prepared by Mr L. S. Bertus.

Key to the entomogenous species of Myriangium.

Stroma at first green internally; ascigerous region cup-shaped. *M. Duriaei.*

Stroma yellow-brown internally; asci in a zone parallel to the surface.

Spores generally oblong-oval, septa distinct. *M. Curtisii.*

Spores generally narrow-oval, septa tardily developed. *M. Montagnei.*

Stroma white internally; asci clavate or pyriform, in a single layer. *M. Thwaitesii.*

EXPLANATION OF PLATES.

Plate II.

Fig. 1. *Myriangium Duriaei*, stroma with apothecia (England). ×6.
2. *M. Duriaei*, lower surface of stroma (England). ×6.
3. *M. Duriaei*, convex apothecia (England). ×6.
4. *M. Duriaei*, an apothecium (England). ×15.
5. *M. Duriaei*, *ex* co-type of *M. philippinense*. ×6.
6. *M. Curtisii*, stroma with two open apothecia (America). ×6.
7. *M. Thwaitesii* (Ceylon). ×6.
8. *M. Montagnei*, large open apothecia (Australia). ×6.
9. *M. Montagnei*, stroma bearing stout-edged apothecia (Australia). ×10.
10. *M. Montagnei*, stroma with convex apothecia (Australia). ×6.
11. Mature elliptic ascus of *M. Duriaei* (France). ×600.
12, 13. Mature asci from the same apothecium of *M. Duriaei* (England). ×600.
14. *M. Duriaei*, broken ascus (below) with extruded hyaline plasma containing the spores (Ceylon). ×500.
15. Spores of *M. Duriaei* (England). ×600.
16. Spores of *M. Curtisii* (America). ×600.
17. Spores of *M. Montagnei* (Australia). ×600.
18. Asci of *M. Thwaitesii*. ×300.
19. Spores of *M. Thwaitesii*. ×600.
20. *M. Duriaei*, broken ascus with extruded hyaline plasma from which the spores have escaped (Ceylon). ×300.

Plate III.

1. *M. Duriaei*, vertical section through an apothecial process and part of the base of the stroma. ×40.
2. *M. Duriaei*, vertical section of a stroma, showing a shallow apothecium. ×25.
3. *M. Duriaei*, vertical section of a pulvinate stroma from the same gathering as Fig. 1. ×25.
4. *M. Curtisii*, vertical section of a single apothecial process. ×40.
5. *M. Montagnei*, vertical section of a stroma. ×18.
6. *M. Montagnei*, vertical section through an apothecial process. ×40.
7. *M. Montagnei*, vertical section through an unopened process. ×40.
8. *M. Thwaitesii*, vertical radial section through half the stroma, ×40: the lower part of the figure shows the tissues of the host plant, and the central cavity is the perithecium of another fungus immersed in those tissues.
9. *M. Thwaitesii*, vertical section through a process. ×125.

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THREE DISEASES OF CULTIVATED MUSHROOMS.

(With Plates IV and V.)

By F. E. V. Smith, B.Sc.

INTRODUCTION

Throughout the history of mushroom growing, the disease known as "la molle" has been recognised as the growers' most serious enemy. It occurs in all the districts in England where mushrooms are cultivated. Generally the attacks do not reach epidemic proportions but the disease occurs regularly with each crop of mushrooms and does sufficient damage to make an appreciable reduction in the profits, even if actual loss is not experienced. Epidemics are not infrequent in France and America, cases being on record where the industry has had to be abandoned through the ravages of this disease. The only means of control in use in England appears to be that of burning the diseased mushrooms. On the continent disinfectants have been used as preventatives with a fair measure of success.

The object of the present investigation was to study the disease as it appears in England and to see if the results of the investigations of Costantin and Dufour in France or Veihmeyer in America applied in this country also. Although the investigation was originally intended to cover only the disease caused by *Mycogone perniciosa*, it was found that the mushrooms which the grower calls "diseased" may contain one of three parasitic fungi and consequently the three diseases were investigated.

HISTORICAL.

The earliest scientific records of the *Mycogone* disease of mushrooms are those of Magnus (1888) and Cooke (1889). Magnus was unable to identify the fungus with any known species and so, although the ascus stage was not seen, he named it *Hypomyces perniciosus* by analogy with *H. chrysospermus*. Cooke stated that the fungus he found resembled both *Mycogone rosea* and *M. alba* but differed in having amber-coloured chlamydospores.

Several papers followed these in which the parasitic fungus was identified as, or referred to, the following species: *Verticillium agaricinum* (Stapf 1889); *Mycogone rosea* (Prillieux 1892); *Mycogone cervina* (Costantin and Dufour 1892); Costantin and Dufour made a very exhaustive study of the disease and after

growing the fungus side by side with *M. rosea* decided that it was a distinct species and named it *Mycogone perniciosa* (Magnus). This name has been adopted by all subsequent writers, but the systematic position of the fungus has never been thoroughly investigated. It seems remarkable that if the fungus is a distinct species it should not have been recorded in the wild state.

Costantin and Dufour investigated the fungus very thoroughly and found that it exhibited two forms of spores on the mushroom. The first to appear was a *Verticillium*-like spore which was quickly followed by the chlamydospore or *Mycogone* stage. By making separate cultures from these two spore forms they proved that they belonged to one fungus, since the growths which resulted were identical in all respects, and the two types of spore were borne on each. The diseased mushrooms were divided into two categories by these workers, namely the "commune" and the "sclérodermique" forms. The first group included those mushrooms which retained the normal shape with only slight deformity. The disease appeared on these externally as a white felt either on the stipe or on the under surface of the pileus. The second group was characterised by much greater deformity, and only those mushrooms which had a very much swollen base and greatly reduced cap were included. Quite often the pileus was entirely wanting, and such forms were called "sclérodermique" because of their resemblance to the genus *Scleroderma**. On further study it was found that neither the *Verticillium* nor the *Mycogone* spores were produced on the sclerodermoid mushrooms, but another fungus having small spores invariably appeared. This was described as "*Verticillium* à petites spores." In culture it consistently produced small spores only. It was concluded, however, in spite of this, that it was a stage of *Mycogone perniciosa* because in one instance the two fungi were found on the same mushroom. In this case they observed what were considered to be stages in the transition between the small- and large-spored *Verticillium*. This was the only observation on which the identity of the three forms was based.

In 1909 considerable outbreaks of the disease occurred in America. This epidemic was investigated by Veihmeyer (1914), who was successful in finding measures which prevented the occurrence of the disease. He found that the two types of diseased mushrooms described by the French writers were also produced in America, but he was unable to isolate or observe any fungus resembling the small-spored *Verticillium*. A *Myco-*

* For the sake of convenience the word "sclerodermoid" has been substituted for "sclérodermique" in this paper.

gone was isolated which agreed with *Mycogone perniciosa* in all respects, but it could be isolated from both the ordinary and the sclerodermoid types. Veihmeyer carried out a large number of experiments on the longevity of the spores of *Mycogone* and their resistance to certain disinfectants, notably coal oil and formaldehyde gas.

The results of these two investigations appeared to be contradictory on the question of the causal organism of sclerodermoid mushrooms. The results of the present investigation show that sclerodermoid mushrooms may be produced by two separate parasites.

THE MYCOGONE DISEASE.

(*a*) *The Diseased Mushrooms.*

In mushroom houses where *Mycogone perniciosa* has once appeared and where effective control measures are not in use, attacks of the disease occur in every set of beds made. It does not make its appearance at any particular time during the growing period of the bed, but appears sometimes when the mushrooms are just beginning to form, while in other cases evidence of the attack is not visible until the beds are beginning to "go off." The writer's experiments show that the chief factor determining the time of appearance is the quantity of infection. When there is a heavy deposit of *Mycogone* spores the attack usually appears with the first mushrooms, while a lighter infection does not produce many diseased specimens until the bed has reached the optimum of its growth.

Mushrooms infected by *Mycogone* are usually deformed (Plate V, fig. 8). In some instances the mushrooms show no outward signs of infection except deformity, while others appear quite normal in shape but bear a dense flocculent felt of parasitic mycelium either on the stipe or the gills. It is comparatively rare to find mushrooms with the parasite on the upper surface of the pileus.

The presence of the disease internally causes the mushroom to produce a very much enlarged stipe. This affects the development of the other parts so much that very often the pileus and gills are considerably reduced or entirely absent.

Thus there are transitions between two extreme types of infection from the normal mushroom with an external infection to the spherical sclerodermoid form which frequently does not show any of the parasite externally.

(*b*) *The Parasitic Fungus.* Mycogone perniciosa.

Mycogone perniciosa produces a copious flocculent mycelium on most substrata. In the early stages this is white but later

changes to a light amber brown. The hyphae are narrow (3 to 4 μ wide) and frequently septate, the cells being multinucleate and very rich in cytoplasm. Two types of spores are formed representing conidia and chlamydospores (Plate IV, fig. 1)

The conidia are thin-walled cells borne on upright verticillately branched conidiophores and are known as the *Verticillium* stage. These are the first to appear on the mushroom and may be found always at the edge of the *Mycogone* mycelium. The conidiophores consist of long and frequently branched verticils bearing conidia at the tips of the pointed branches. The conidia are produced by the formation of a constriction near the apex. The portion beyond the constriction enlarges until finally a long cylindrical spore with pointed ends is cut off (Plate IV, fig. 3). When the formation of the conidium is practically complete a median septum appears. The mature conidium is 1-septate with equal sized cells. The size of those growing on mushrooms varies between 15 to 20 μ in length with a diameter of 3 to 4 μ. The walls are quite thin and usually one or more oil drops may be seen in each cell. The frail connection between the conidiophores and conidia causes them to be shed frequently before maturity while they are still unicellular*. In some of these cases septa are formed afterwards but frequently the spores remain unicellular. Germination takes place quite readily from either one or both cells of the spore.

The chlamydospores (*Mycogone*) are formed later on short branches at the base of the *Verticillium* conidiophores and are much more resistant than the thin-walled conidia. The end of the hypha swells slightly and divides by one transverse septum. The upper cell thus formed swells more quickly than the lower and its wall thickens. Finally, a bicellular spore is formed, the upper cell of which is almost spherical with a thick stratified wall. The outer surface of the upper cell is slightly warted and the cytoplasm is dense and granular, containing several nuclei (Plate IV, fig. 2). The mature spore is light umber in colour. The lower cell remains almost unthickened and is smaller than the other. It appears to act only as a suspending cell for the upper thickened part of the spore as it is easily ruptured, and is often torn when the spore is shed. It is possible that the shedding of spores is effected by the death of these suspending cells for they do not play any part in the life of the spore afterwards. The size of the mature spore varies according to the medium on which the fungus is grown, but on mushrooms and on several agar solutions the complete bicellular spore measures from 25 to 30 μ in length at maturity. The upper thickened cell is from

* Since the majority of the spores are uniseptate, this stage would be more correctly described as the *Diplocladium* stage.

18 to 20 μ broad and 14 to 17 μ long, while the suspending cell is rarely more than 10 to 14 × 9 to 12 μ. The thin lower cell dies quickly and germination is effected by the production of a germ-tube which usually arises at the base of the upper cell. The young hypha penetrates the thinner portion of the spore wall at the base and then passes through the cavity left by the dead suspending cell. Satisfactory germination studies are difficult to carry out in hanging drops, and it has been found that the best method is to place drops of spore suspension on a mushroom agar plate. Spores removed after two days usually show stages in germination.

(*c*) *Culture Studies in Mycogone.*

In his monograph on *Hypomyces*, Plowright (1882) states that in most species of this genus the ascigerous stage is most likely to appear when the formation of chlamydospores is retarded or prevented. By analogy with other fungi it seems obvious that when the food supply is of a favourable nature the ordinary (*Verticillium*) conidia will be produced and that the fungus will be stimulated to form chlamydospores when the food supply runs short or is unfavourable. In order to test Plowright's statement and also to try to find the conditions under which the two types of spores are produced, a large number of cultures were made on various media.

In the first place, the usual series of stock agars and gelatines were used; but as the food conditions are not the only factors which might influence the growth of the fungus, variations of temperature, light and acidity were made in these experiments.

Light and darkness seem to have little or no effect, but it was soon discovered that higher temperatures accelerate growth up to an optimum of 23° to 25° C. Similarly, a higher humidity produces a much more flocculent culture, but neither of these conditions influences the proportion of either sort of spore formed beyond what would be naturally expected from a more vigorous culture.

The effect of various food materials on the quantity of spores produced is most striking. When the fungus is grown on media rich in carbohydrates such as potato, prune, macaroni and rice the growth is quite brown from the large number of chlamydospores formed. In other cases where more nitrogenous foods are available, such as nutrient agar and gelatine, mushroom agar and extract and solutions containing peptones and amino compounds, the proportion of *Verticillium* spores is considerably larger.

Zellner (1907) gives a brief analysis of the substances present in *Psalliota arvensis* and *campestris*. Using this analysis as a basis for a stock culture solution, a number of semi-quantitative

culture experiments have been made. The stock solution contained:

Potassium sulphate	4 grams.
Potassium hydrate phosphate	1·5 ,,
Sodium nitrate	1·0 ,,
Sodium chloride	1·0 ,,
Traces of ferrous sulphate and magnesium sulphate	
Water	1000 c.c.

The experiments consisted in growing *Mycogone* in tubes or flasks of this solution to which had been added substances of known composition. The results are summarised in Table I.

Table I.

Constituents added to stock solution	10 days' growth	25 days' growth	3 months' growth
A. 0·25 % each asparagin, leucin and urea	¾ inch diameter, white, sterile	2 inches white, sterile	liquid filled with white, sterile hyphae
B. 0·25 % mannite, dextrose	¾ inch white, sterile	buff to whitish, many chlamydospores, no *Verticillium*	liquid filled with mycelium, surface brown and powdery with chlamydospores
C. 0·25 % each asparagin, leucin, urea, mannite, and dextrose	1 inch, sterile	2 inches, buff, few *Verticillium*, chlamydospores frequent, not so abundant as in *B*	similar to *B* but chlamydospores not so numerous, estimated at half the number

These experiments were carried out with six tubes of each variety in order that a tube might be opened for each examination. In the case of *A* it was necessary to ascertain that the fungus was *Mycogone perniciosa*. Transfers to tubes of mushroom agar confirmed this. The experiments show that carbohydrates stimulate the formation of chlamydospores, while purely nitrogenous substances inhibit the formation of both kinds of spores. So far the writer has not found conditions favourable to the formation of *Verticillium* spores only.

(*d*) *Pathological Anatomy.*

A microscopical examination of mushrooms which have only an external infection shows that the mycelium of the parasite penetrates to a considerable depth into the mushroom tissue*.

* The *Mycogone* hyphae are easily distinguished from those of the mushroom when sections are stained in Delafield's Haematoxylin and Safranin. The parasitic hyphae are very much smaller and take up more stain owing to the greater concentration of cytoplasm. The normal diameter in *Psalliota* is about:

Stipe	inner cells 8–14μ	
	outer ,, 6–9μ	
Gills	inner cells 4–7μ	often less
	outer ,, 5–9μ	
Pileus	inner cells 8–12μ	
	outer ,, 5–7μ	

Mycogone hyphae have an average diameter of 3–4μ.

The hyphae of *Mycogone* penetrate the host by passing between the plectenchymatous cells. Enzyme secretion is very vigorous, and in prepared sections there is always a deeply stained zone around the hyphae which are growing vigorously. A section through the infected portion shows four distinct bands (Plate IV, fig. 4). The outer layer consists of a thick felt of hyphae of the parasite bearing chlamydospores and bicellular conidia. Adjoining this is a zone of brown mushroom tissue which has been killed. A few parasitic hyphae pass through this region connecting the outer felt of hyphae with the inner living tissues of the mushroom.

Inside the zone of dead tissue are two layers of mushroom hyphae in various stages of infection. In the outer layer of these there is evidence of extensive enzyme secretion. Hyphae of the parasite are very abundant and pass both between and through the cells of the plectenchyma, which show signs of disintegration. Occasional chlamydospores are formed in this region. The innermost zone has fewer parasitic hyphae as infection takes place from the outside inwards. Here the *Mycogone* hyphae pass between the host mycelium, and in some cases just penetrate the cell walls.

It appears that most of the damage is caused by enzyme action, for once infected, the mushroom quickly decomposes and becomes soft and odoriferous. To test this suggestion several cultures of *Mycogone* were made on aqueous mushroom extract in Erlenmeyer flasks. When the surface of the culture fluid was covered, the mycelium was removed and ground in a mortar with a little cold water. A piece of mushroom stipe on being treated with the filtrate from this mixture quickly became soft wherever it was thoroughly wetted.

In some cases infection takes place when the mushroom is quite small and the parasite travels upwards through the inner tissues of the stipe and finally enters the pileus. Usually the number of hyphae which pass upwards in this way is relatively small, but once the hyphae enter the pileus they commence active ramification and finally pass down the gills and burst through the hymenium, which soon becomes covered with a white flocculent felt.

SCLERODERMOID MUSHROOMS.

(*a*) *Mycogone perniciosa.*

Veihmeyer's work indicated that *Mycogone perniciosa* was present in sclerodermoid mushrooms and that the "*Verticillium* à petites spores" of Costantin and Dufour was not necessarily the parasite which produced this type of infection. A number of experiments have been carried out on mushrooms grown in

specially constructed boxes with the object of testing the statements of these two writers and also to make observations on the methods of infection by *Mycogone*. These boxes were made with a deep lid in order that the mushrooms might have plenty of air without great risk of stray spores of *Mycogone* or other fungi entering.

Mushroom beds infected by spraying or sprinkling with a suspension of *Mycogone* spores in sterile water produced mushrooms with an external infection and, in addition, a considerable number of sclerodermoid mushrooms. Isolations were made from both of these types and *Mycogone* occurred invariably not only in the culture tubes but also on all of the mushrooms themselves. In the control boxes the mushrooms were all perfectly normal. This experiment was repeated on several occasions with the same results, showing quite clearly that sclerodermoid mushrooms may be produced by *Mycogone perniciosa.*

It has been suggested that *Mycogone* attacks the spawn and that the parasitic hyphae mingle and grow side by side with those of the mushroom, finally entering the young sporophore. Careful observations were therefore made to ascertain the method of infection, and it seems quite clear that *Mycogone* infects each mushroom separately. Numerous specimens of spawn have been taken from diseased beds and examined microscopically, but none of these contained parasitic hyphae below the level of the soil except in one or two instances. These were cases when a heavy infection of spores had been mixed with the lower layers of soil, or with the dung, or else placed directly on the spawn itself. In these cases the spawn died very quickly and only one or two mushrooms were produced. It is very improbable that the parasite could grow in contact with the mushroom hyphae for any length of time, as *Mycogone* produces enzymes which rapidly break down the hyphae of the mushroom. The observations made on the beds used in this investigation lead one to believe that *Mycogone* infects the very young mushrooms from the soil. That it is capable of living and growing in the soil has been shown by cultures made on all types of soils available. It appears that the type of mushroom produced varies with the degree of its development at the time of infection. Thus sclerodermoid mushrooms develop from an infection previous to the differentiation into stipe and pileus while those with rudimentary caps become infected at a slightly later stage. This has been shown in beds which have been infected by spraying when the first mushrooms had arrived at the "pin-head" stage. Allowing two or three days for the germination of the *Mycogone* spores, it can be reckoned that differentiation had well begun in the larger mushrooms when infection took place. The first mushrooms to

appear in this experiment were either undiseased or had only a small external infection. The mushrooms which appeared later were more and more heavily infected until finally they were practically all either sclerodermoid or very much deformed. A similar state of affairs occurs to a smaller degree in most infected beds, the sclerodermoid mushrooms appearing more abundantly as the bed becomes older. This is partially accounted for by the many broken strands of mycelium left when the diseased or healthy mushrooms are removed. These broken ends frequently round off and form new buttons which are readily attacked by the *Verticillium* spores (conidia) liberated from those mushrooms which have been removed.

Mushrooms frequently arise in clusters and it is not uncommon to find all types of diseased and healthy mushrooms in the same cluster (Plate V, fig. 8). This may be explained by one or two of the older specimens having been infected from the soil and the disease passing from them to those which are less developed.

(*b*) *Cephalosporium.*

During the summer of 1923 the writer obtained specimens of diseased mushrooms from growers in four different districts in order to isolate the fungi present in them. Isolations were made by cutting out a small cube of the diseased tissues with a sterile scalpel and after being passed through a flame it was transferred to a tube of culture medium*. The cultures were stored in a cool cupboard to reduce bacterial growth to a minimum.

In three of the consignments received most of the mushrooms were of the slightly deformed type—typical of *Mycogone* disease. In all these cases *Mycogone* appeared both in culture and on the mushrooms themselves. Only one mushroom in these three consignments was similar to the sclerodermoid mushrooms grown by the writer. This specimen produced *Mycogone perniciosa* on its cut surfaces, and also pieces placed in culture tubes showed the same fungus.

The fourth consignment was quite different from the others, all the mushrooms being either spherical or invertedly pyriform. They differed from the sclerodermoid mushrooms which the writer had been acquainted with previously, not in shape but in texture and in appearance. The sclerodermoid forms in which *Mycogone* is present are usually whitish, very soft and moist in texture and putrefy very quickly. This sample, however, was

* For this purpose acidified carrot, mushroom or coconut agar or carrot slants are most suitable. Coconut agar is an excellent medium and is prepared from a decoction of 65 grams of commercial desiccated coconut in 1000 c.c. water.

dry and elastic while the surface was light to dark brown and slightly hairy, exactly similar to the surface of the pileus of *Psalliota arvensis**.

The mushrooms did not decompose very quickly and in culture produced, without exception, a fluffy quickly growing fungus which was perfectly white. The same fungus appeared on the cut surfaces of the mushrooms. Several samples of mushrooms from this source have been received from time to time, and invariably the same fungus has appeared. There were a few mushrooms amongst these consignments which have the slight deformations typical of the *Mycogone* disease. In these few cases *Mycogone* has been isolated, but the same white fungus has occurred in all the sclerodermoid mushrooms received from this grower.

On examining this fungus microscopically it was found to consist of frequently branched hyphae with masses of small hyaline spores exactly similar to the spore masses in the genus *Cephalosporium* (Plate IV, fig. 6). The fungus remained constant when grown on all types of substrata and no other method of reproduction has occurred. On comparison with the description by Costantin and Dufour of their "*Verticillium* à petites spores" it was found to agree exactly, and it is concluded that these sclerodermoid mushrooms are identical with those found by Costantin.

The fungus does not appear to have been further described, and the name *Cephalosporium Costantinii* is proposed for it.

Cephalosporium Costantinii nov. sp. Mycelium, white, floccose. Hyphae, creeping, septate, 0·75 to 1·25 μ in diameter, frequently and more or less regularly branched. The branching is frequently subverticillate in the upright portions. Conidiophores, continuous, occasionally cut off at the base by a septum, lateral or terminal, of varying lengths arising either on the main or lateral branches of the hyphae, upright or subdecumbent, of the same diameter as the hyphae. Conidia, oval to subreniform, hyaline, unicellular, 3 to 4 μ × 1 to 1·5 μ, occasionally longer (7 μ), usually broader than the conidiophore. Conidia are cut off singly at the end of the conidiophore but remain clustered around the tip in spore masses. Spore masses, large up to 50 μ in diameter, containing large numbers of conidia, semi-persistent.

[*Cephalosporium Costantinii*. Mycelium album, floccosum. Hyphae repentes, septatae, 0·75–1·25 μ diam., saepe et plus minusve regulariter ramosae, ramis erectis saepe subverticillatis. Conidiophora aseptata, interdum ad basim versus uniseptata,

* The cultivated mushroom is often a variety of *P. arvensis*.

lateralia terminaliave longitudine variabilia, e hypha primaria vel e ramis exorta, erecta vel subdecumbentia, 0·75–1·25 μ diam. Conidia ovalia vel subreniformia, hyalina, unicellularia, 3–4 μ × 1–1·5 μ, interdum longiora (7 μ) quam conidiophora plerumque crassiora, singulariter e conidiophori apice abstricta, sed in capitula collecta. Capitula ad 50 μ diam. e conidiis numerosis composita, semipersistentia.]

In pure culture the fungus grows rapidly and is perfectly white. Spores always produced in large numbers.

As this fungus remains perfectly uniform in culture and shows no signs of any relation with *Mycogone perniciosa* it is concluded that the sclerodermoid disease may be caused by the two fungi separately. This suggests the reason why Veihmeyer's results did not agree with those of Costantin, as *Cephalosporium Costantinii* possibly does not exist in the American mushroom beds. The full pathology of the disease has not yet been worked out.

The measures which control the *Mycogone* disease apply also to *Cephalosporium Costantinii*, but as the latter grows much more readily on sterile dung and pieces of spawn it is probable that the disease is distributed by means of the spawn much more easily than is *Mycogone perniciosa*.

GILL MILDEW DISEASE.

In the spring of 1923 many of the mushrooms in the control beds had a slightly abnormal appearance. The shape of the fructification was quite normal, but closer examination revealed fasciation and mildewing of the gills (Plate V, fig. 9). In the first instance the abnormality was attributed to the stimulus of cultivation, as it is not infrequent to find fasciations in plants which have been subjected to excessive cultivation and nutrition. When pilei of these abnormal mushrooms were placed under a bell-jar in the laboratory, a fine web of white fungal hyphae appeared on the surface of the gills in a very short time, and as this occurred on several occasions it was assumed that the fasciation was caused by a parasitic fungus.

Isolations were made on agar from pieces of the gills of young affected mushrooms and in each instance the same fungus was produced and this was identical with that which appeared on those pilei which were kept in the laboratory. As the fungus appeared in isolations made on several different occasions it was assumed that it was causing the disease. The writer has been unable to trace any descriptions of a similar disease in the literature and proposes the name "Gill mildew" for it.

The gills of the young affected mushrooms in addition to the fasciations have a mottled appearance which later changes to a

uniform glaucous pink. In the later stages the gills become black with a fine web of mycelium covering them. The amount of the fasciation varies, but the lamellae are frequently fused in numbers of three to seven either entirely or in several places along their length.

Since its first appearance the disease has occurred in practically every bed which has been planted, and isolations from mildewed specimens at various times have shown that the same fungus is always present.

It has not been possible to obtain very much information as to the distribution of this disease, but specimens of affected mushrooms have been found growing "wild" on heaps of horse dung, and samples have been seen frequently among those exposed for sale in a town in the north of England. Specimens have also been seen in other places, but it has not been possible to trace the origin of any of these samples. It is assumed, however, that the disease is fairly widespread but practically unnoticed owing to the very small amount of damage done to those mushrooms which are affected. .

The diseased mushrooms appear to be quite edible unless they are kept for some time, when the parasite produces putrefaction of the gills. The parasitic hyphae penetrate the gills but do not appear in great numbers until the later stages. They do not grow or secrete enzymes so vigorously in the mushroom tissues as do those of *Mycogone* and consequently the damage is very small. In pure culture the fungus appears as a white fluffy mycelium which produces small hyaline conidia in very large numbers. The rate of growth is high, particularly when the temperature is raised to 23° to 25° C. This indicates that the damage caused by this disease will be much greater when the weather is warm or when mushrooms are grown in a house which is too hot. The fungus grows very rapidly on sterilised dung and for this reason it is possible that it is really a coprophilous saprophyte which becomes parasitic under certain conditions.

The writer has been unable to find any means of controlling the disease, but as the damage done is not usually very severe it is questionable whether it would be profitable to undertake control measures which entailed much expense.

The parasitic fungus grows rapidly on all substrata and forms a dense white mycelium practically identical macroscopically with *Cephalosporium Costantinii* except that it is not quite so floccose. One type of spore only is formed but these are exceedingly numerous (Plate V, fig. 7).

As the fungus does not appear to have been previously described, the name *Cephalosporium lamellaecola* is proposed for it.

Cephalosporium lamellaecola nov. sp. Mycelium, white, somewhat floccose. Hyphae, creeping, septate, 0·75 to 1·25 μ, in diam., frequently and more or less irregularly branched. Conidiophores, continuous, upright to subdecumbent, of varying lengths often short (15 to 100 μ), occasionally cut off at base by a septum, arising as lateral branches of main hyphae, diameter same as the hyphae. Conidia, oval, hyaline, unicellular, 3 to 5 × 1·5 μ, occasionally longer (7 μ) or subglobose (2 μ), arising singly at the end of the conidiophore but frequently remaining in small temporary clusters (spore masses) of 3 to 10 around the tips of the conidiophores. Spore masses, small, not always spherical, frequently fan-shaped (6 to 10 μ broad), more abundant on older mycelium. Growth is rapid in pure culture.

[*Cephalosporium lamellaecola.* Mycelium album flocculosum. Hyphae repentes septatae 0·75–1·25 μ diam. saepe et plus minusve irregulariter ramosae. Conidiophora aseptata, erecta vel subdecumbentia, longitudine variabilia saepe brevia (15–100 μ), interdum ad basim versus uniseptata, e hypha primaria lateraliter exorta, 0·75–1·25 μ diam. Conidia ovalia, hyalina, unicellularia, 3–5 μ × 1·5 μ, interdum longiora (7 μ) vel subglobosa (2 μ), singulariter e conidiophori apice abstricta, sed acervulos parvos temporarios (3–10-nas), apicales efformantes. Capitula parva, spherica vel conica 6–10 μ diam., in mycelio vetusto abundantia.]

Cephalosporium lamellaecola differs from *C. Costantinii* in the method of branching which is never subverticillate, in the size of the spore masses which are small, ephemeral and frequently fan-shaped and in the spores not being so constant in shape. There is very little difference in macroscopical appearance in culture except that *C. lamellaecola* is not so floccose as *C. Costantinii*.

At first it was thought that the two species might be identical or biological varieties of the same species. When mixed cultures were made with *Mycogone perniciosa*, however, it was found that the two species behaved very differently. The cultures were made on agar plates, inoculations of *Mycogone* being made on one side with one of the two species of *Cephalosporium* on the other. After incubation at 22° C. for a week *Cephalosporium Costantinii* showed attraction for *Mycogone* while *C. lamellaecola* exhibited strong repulsion. The shape of the growths in *C. Costantinii* were semi-circular, meeting at the broadest parts. The growths in the other case were shaped like a sector with an angle of 110°, the two angles being opposite. In the latter case only very little growth occurred in the region between the two points of inoculation.

As these experiments were repeated on several occasions with exactly the same results, it is quite clear that the two fungi are distinct although their appearance is very similar.

CONTROL MEASURES AND METHODS OF PROPAGATION OF THE MYCOGONE AND SCLERODERMOID DISEASES.

When a mushroom house is once infected with *Mycogone*, it can only be cleared of the disease by rigorous and careful disinfection of every part of the house and all implements, etc., which have come in contact with the diseased mushrooms. In many instances growers are exceedingly careful to remove all diseased mushrooms and all the dung and soil, but omit to disinfect the floor, walls, and roof. In consequence a number of spores which are carried into crevices by draughts remain untouched. A number of these spores are bound to be dislodged each time there is any draught, and so they are spread over the surface of the new beds with the result that crops are always infected.

For experimental purposes beds have been made in specially constructed boxes, and many infection experiments have been carried out to investigate the conditions suitable for the propagation of the disease. The boxes used for these experiments were designed so that observations could be made while keeping them as free as possible from outside infections.

From these experiments the following facts have been ascertained:

(1) Soil from infected beds is capable of infecting a second bed.

(2) Infected soil treated with 2 per cent. formalin and dried ceases to cause infection. (A control experiment was made at the same time, using untreated soil.)

(3) Small portions of dung from the surface of infected beds are capable of distributing the disease.

(4) The following solutions when used as a spray are perfectly effective for disinfecting the boxes, and it is to be expected that they will prove equally as efficient when used on a large scale:

1·5 to 2 per cent. lysol.
2 per cent. formalin.
2 per cent. phenol.
1·5 to 2 per cent. of the proprietary brands of coal-tar disinfecting fluids.

(5) 1·5 per cent. copper sulphate will kill spores with which it comes in contact, but in practice it does not seem to percolate so well as the other solutions and has proved to be insufficient for soil sterilisation.

Further experiments have been made, using a suspension of *Mycogone* spores in distilled water for the purpose of infection.

Successful infections have been made when this suspension has been used in the following ways:

(1) When placed on the spawn before being put in the bed —few infections only, but a very small crop of mushrooms, indicating that the spawn was killed by the disease.

(2) When sprayed on the top of the dung—more than 50 per cent of mushrooms infected, but a very poor crop.

(3) When mixed with the soil—90 per cent. infection.

(4) When sprayed on the surface of the bed—from 75 to 90 per cent. infection.

Infection takes place quite as readily when lime is added to the soil as it does when ordinary loam is used. Culture experiments show that *Mycogone* will grow in dung and all types of soil available both with and without the addition of lime. The growth was not large in these cultures but nevertheless it penetrated right through the various soils. It appears that when spores of *Mycogone* fall on the surface of the beds, they germinate and continue to live in the soil or dung until they reach the spawn or young mushrooms.

It is impossible to apply control measures which will affect the disease and yet leave the mushrooms unhurt. The method which has proved most efficient in dealing with the disease is that of watering the diseased portions of the beds with one of the disinfecting fluids mentioned. This, however, kills the mushroom spawn also. Diseased mushrooms should be removed and burnt as soon as possible, while the bed within a radius of two or three feet of the spot whence they are taken should be treated with disinfectant. Sufficient solution should be applied to saturate the bed to a depth of several inches. Formalin is preferable for this purpose as the gas given off kills the mushroom fly which is one of the chief distributing agents inside the houses. Disease appeared in a box which was previously free, after a number of flies taken from a diseased mushroom were placed inside the cover. Cultures of *Mycogone* and *Cephalosporium* have also been made from these flies.

When the bed has finished cropping, the manure and soil should be removed to a considerable distance and the latter never used for the purpose again unless treated with formalin. If it is inconvenient to remove this from the farm or garden in which the mushroom houses are situated, it should be treated with disinfectant or quicklime.

The floors of the houses should be sprinkled with unslaked lime, and the walls thoroughly sprayed with disinfectant, the spray being directed into all the crevices. In very severe cases it is advisable to fumigate the houses with formaldehyde gas before anything is removed. Veihmeyer (1910 and 1914) recommends

using 3 pints of formalin (40 per cent.) to 1½ lbs. of potassium permanganate for 1000 cubic feet. Fumigation sterilises the beds, walls, and roof as the gas enters all the crevices, at the same time killing the mushroom fly which is instrumental in spreading the disease. It is hopeless to try to destroy the disease unless these measures are carried out, since the chlamydospores of *Mycogone* are capable of very long life, the thick wall making them resistant to extremes of atmospheric conditions.

Growers should also realise that it is essential to obtain spawn from a thoroughly reliable source. The writer has examined the beds of one of the largest growers on several occasions. On this mushroom farm quicklime is used liberally on the floors when the beds have been removed, so that the disease spores cannot be carried on the employee's boots. The implements are frequently disinfected. The result is that, although some twenty acres of floor space are in use and three-quarters of a ton of marketable mushrooms are gathered weekly, no *Mycogone* has ever appeared. This grower makes his own spawn under strictly aseptic conditions, and it behoves all growers who wish to increase their yield of marketable mushrooms, either to follow this example or else to buy spawn which is known to be made under disease-free conditions. The experiments which have been described show that the disease can be carried by spawn.

Some growers have houses made with low-thatched roofs, nothing being placed inside the straw. This method cannot be too strongly condemned as the straw harbours both spores and the flies which carry them. Whenever the straw is touched a number of spores are shaken on to the beds beneath. In one set of such houses which were examined the grower stated that he had never had a bed of mushrooms which were entirely free from the disease.

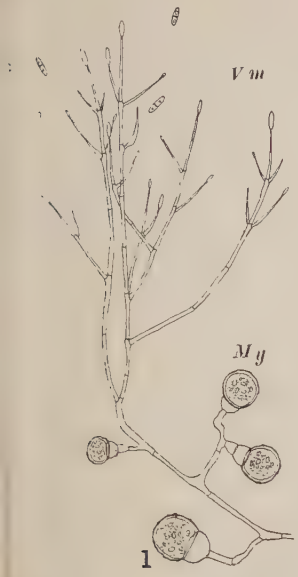
SUMMARY.

1. Mushrooms are subject to disease caused by one or any of three parasitic fungi, *Mycogone perniciosa, Cephalosporium Costantinii* n.sp., or *Cephalosporium lamellaecola* n. sp.

2. Sclerodermoid mushrooms may be produced by *Mycogone perniciosa* or *Cephalosporium Costantinii*, the latter being identical with the "*Verticillium* à petites spores" of Costantin and Dufour.

3. The pathology of *Mycogone perniciosa* has been investigated in detail. It is shown to be distributed by infected soil or spawn; usually each mushroom is infected directly from the soil in the early stages of its development.

4. *Mycogone perniciosa* may be controlled by fumigation or spraying with formalin or lysol and by soil sterilisation.



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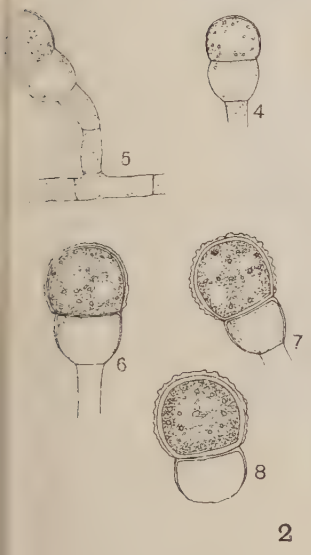

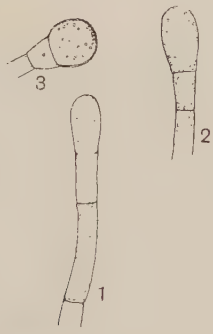

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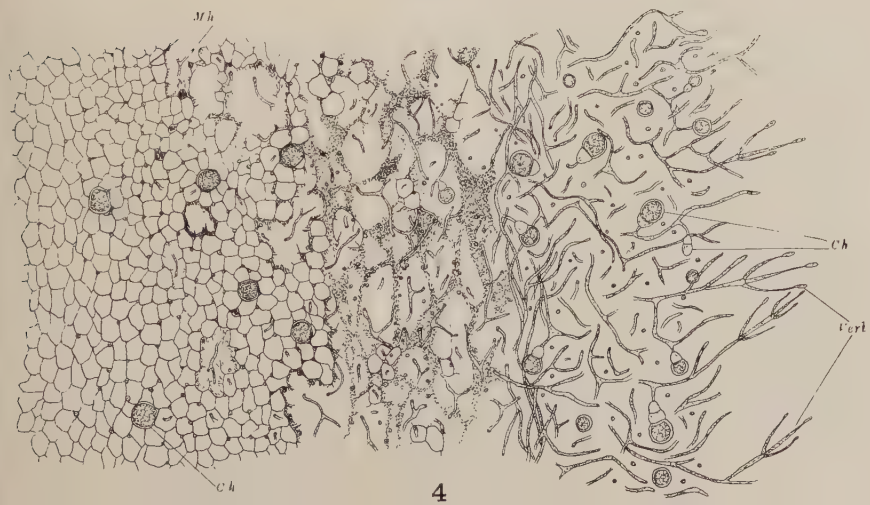

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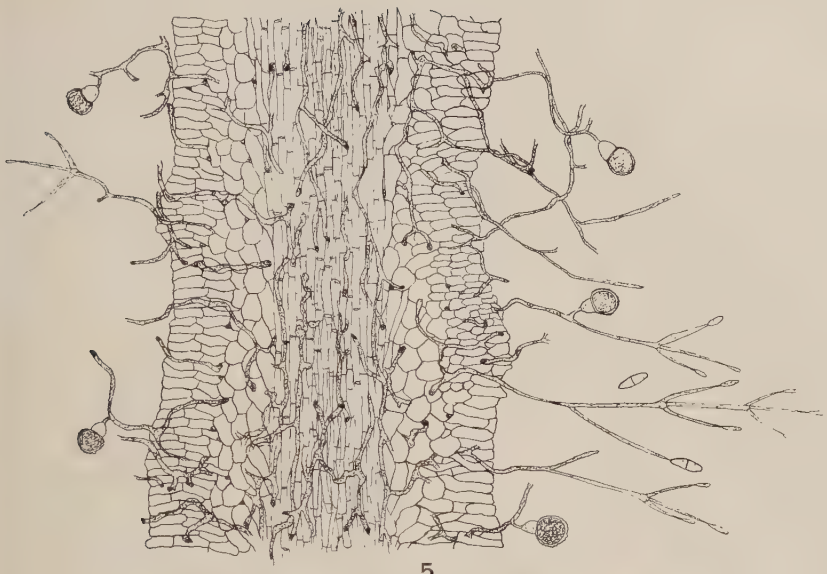

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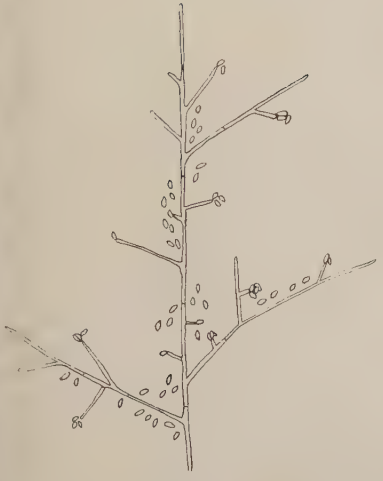

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The writer wishes to thank Mr J. Ramsbottom, M.A., O.B.E., for his great help in the systematic work. Prof. O. V. Darbishire, B.A., Ph.D., suggested this investigation to the writer who owes him many thanks for his constant interest, help, and advice during the progress of the work. The Department of Scientific and Industrial Research gave a grant in aid of the investigation and the Colston Research Association of Bristol University has kindly made a grant towards the cost of the plates illustrating the paper.

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Jan. 1924.

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EXPLANATION OF PLATES IV AND V.

Fig. 1. *Mycogone perniciosa.* Portion of mycelium showing verticillate conidiophore bearing *Verticillium* conidia (*Vm*) and chlamydospores (*My*). × 250.

Fig. 2. *M. perniciosa.* Stages in the development of chlamydospores. (9) First stage in germination. × 500.

Fig 3. *M. perniciosa.* Stages in the development of the *Verticillium* spore. × 600.

Fig. 4. *M. perniciosa.* Transverse section of stipe of diseased mushroom, showing outer layer of parasitic hyphae; the zone of dead tissue and the inner zones where the *Mycogone* hyphae are penetrating between the plectenchymatous cells. *Ch*, chlamydospores. *Vert*, *Verticillium* spores. *Mh*, *Mycogone* hyphae. × 160.

Fig. 5. *M. perniciosa.* Transverse section of diseased gills, showing the parasitic hyphae passing down the centre of the gill and finally breaking through the hymenium and forming spores. × 300.

Fig. 6. *Cephalosporium Costantinii.* Showing short conidiophores, spore masses (*S.M.*) × 300 and individual spores (*A*). × 600.

Fig. 7. *Gill Mildew Disease.* Portion of the mycelium of *Cephalosporium lamellaecola* showing short conidiophores, spores and branching. × 300.

Fig. 8. *M. perniciosa.* Photograph of a cluster of diseased mushrooms, showing slightly diseased form and also a sclerodermoid mushroom. Note drops of black liquid exuded, this is rich in destructive enzymes. × ⅔.

Fig. 9. *Gill Mildew Disease.* The underside of a pileus in the early stages of attack by the disease. Note the fasciated gills. × 1.

APPLE ROT FUNGI IN STORAGE.

(With Plates VI and VII.)

By M. N. Kidd, B.A., and A. Beaumont, B.A., Food Investigation Board, Department of Scientific and Industrial Research.

Introduction.

The following account of apple rot fungi is based on a systematic investigation of all the rots which developed on certain groups of apples during the storage seasons 1921–22, 1922–23. One thousand seven hundred and ninety-five isolations have been made and practically all the fungi are now identified. The apples used in the first season were Bramley's Seedling from four localities, each having a different type of soil—Chalk, Fen, Sand and Silt, and, in the second season Bramley's Seedling, Allington Pippin and Bismarck on Chalk. Occasional isolations from other varieties have been included.

The distribution and intensity of attack in storage of the different fungi are not here discussed in detail because they are to be dealt with in another paper by one of the writers (20).

It is well known that many fungi isolated from diseased tissues may not necessarily be responsible for the decay but merely follow the attack of other organisms. On this account, inoculations from single spore cultures of most of the fungi described have been made on healthy apples under controlled conditions, with subsequent re-isolations to establish their pathogenicity.

The inoculation method was as follows. Small pieces of glass tubing about 2 mm. long, previously plugged with cotton wool, were fastened by means of luting wax to the surface of the apple, and then were partially filled with sterile liquid media (having a capacity of less than 1 c.c.), and spores of the fungus sown in the liquid. By this method germination takes place under favourable conditions and every facility is given the fungus to invade the healthy tissue*. The ordinary method of wounding the healthy tissue and inserting the dry spores in the wound was used occasionally.

Historical.

The literature dealing with the fungi which infect apples in storage is very scattered, and as no investigators have hitherto

* This method of inoculation was first worked out by us during the course of research on the factors controlling invasion of fungi—an account of which will appear in due course.

The majority of inoculations were made on Bramley's Seedling.

attempted a detailed survey of such rots it is also very incomplete. In fact much of the existing information on apple rot fungi in storage can only be obtained indirectly.

Schneider-Orelli (33) in Germany, conducting an investigation on the effect of temperature conditions on growth and dissemination of rot-producing fungi on storage fruit, gives the following as occurring on apple:

Botrytis cinerea Pers.
Penicillium glaucum Link.
P. italicum Wehm.
Monilia fructigena Pers.
Gloeosporium fructigenum Berk.
Gloeosporium album Osterw.
Fusarium putrefaciens Osterw.
Cladosporium herbarum Pers.
Mucor piriformis Fisch.
Rhizopus nigricans Ehrenb.

Ames (1), and Brooks and Cooley (2), studying the effect of temperature and growth on the living host with fruit rot fungi in America, give the following as common apple rot-producers:

Monilia fructigena Pers.
Penicillium expansum (Link) Thom.
P. digitatum (Pers.) Sacc.
Rhizopus nigricans Ehrenb.
Glomerella rufomaculans Berk.
G. cingulata Atkins.
Thielaviopsis paradoxa (de Seyn) v. Höhn.
Cephalothecium roseum Corda.
Aspergillus niger van Tiegh.
Botrytis cinerea Pers.
Fusarium radicicola Wollenw.
Neofabraea malicorticis (Cord.) Jackson.
Sphaeropsis Malorum Peck.
Volutella fructi Stev. and Hall.
Pestalozzia funerea Desm.

Él. and Ém. Marchal (24), in a comprehensive account of fungi isolated from rots on different fruits under storage and other conditions in Belgium, give the following as having been isolated from diseased apples:

Diaporthe perniciosa É. and É. March.
Fusicoccum Malorum Oud.
Dothiorella vinosa É. and É. March.
Fuckelia conspicua É. and É. March.
Gloeosporium album Osterw.
Goetrichum candidum Link.
Botryosporium diffusum Corda.
Eidamia acrimonioides Harz.
Penicillium glaucum Link.
P. flavum É. and É. March.
Cephalothecium roseum Corda.
Cladosporium herbarum Pers.
Alternaria tenuis Nees *v.* Mali É. and É. March.
Tilachlidium Malorum É. and É. March.
Isaria felina Fr. *v.* pirina É. and É. March.
Graphium fructicolum É. and É. March.
Stysanus stemonites Corda.
Tubercularia piricola É. and É. March.
Dendrodochium pulchrum É. and É. March.
D. versicolor É. and É. March.
Fusarium Solani Mart.
F. coeruleum Sacc.

Finally Brown (6) working in this country on temperature effects on germination and growth of fungi, and Horne (43), studying the development of apple rot fungi in cold storage, record the following as common rot-producing fungi:

Alternaria Grossulariae Jacz.
Botrytis cinerea Pers.
Sphaeropsis Malorum Peck.
Phoma roseola Desm. (later identified as) Polyopeus purpureus Horne.
Penicillium glaucum Link.
Rhizopus nigricans Ehrenb.
Cephalothecium roseum Corda.

PHYCOMYCETES.

RHIZOPUS NIGRICANS Ehrenb.

We have isolated this fungus only in one or two instances, and always on early varieties of apples such as Stirling Castle. The rot is soft, light brown in appearance and apparently spreads rapidly through the fruit. The mycelium appears through the lenticels and there produces numerous sporangiophores.

ASCOMYCETES.

DISCOMYCETES.

SCLEROTINIA FRUCTIGENA Woron. see *Monilia fructigena* Pers.

PYRENOMYCETES.

PLEOSPORACEAE.

PLEOSPORA POMORUM Horne.

This species was first described as occurring on apple fruit by Horne in 1920 (17). It is very similar in its perithecial stage to both *P. herbarum* Rab. and *P. Lycopersici* É. and É. March. but differs from them in having a conidial stage which resembles the genus Stemphylium instead of Macrosporium.

The Pleospora isolated by us from Bramley's Seedling and other varieties of apple appears to be identical with *P. pomorum* except in the size of its perithecia which are never larger than 600 μ, whereas Horne gives the diameter as about 1 mm.

In culture the fungus grows well on most media, but shows great variability in the development of its reproductive organs when first isolated from the diseased tissue, so much so, as to suggest the presence of distinct physiological strains, although spore measurements and other morphological characters are identical. This variability seems to be lost with subsequent culturing. In some cultures, notably in isolations from Bramley's Seedling off Chalk soil, 1922, masses of conidia with very little mycelial growth were developed in about fourteen days at room temperature; the perithecia appearing much later. In other cases the perithecia developed simultaneously with the conidia or even in advance of them.

Horne (17), in discussing the occurrence of this fungus, considered it to be associated, under natural conditions of the orchard and storage, essentially with "spots" (that is to say, producing small discoloured areas about 2 mm. diameter) and rarely developing into actual rots, although by inoculation experiments he showed it to be capable of parasitising the fruit. We have found that, although frequently isolated from such spots, it is also responsible for quite appreciable loss during storage.

The rot can be easily recognised. It usually arises at a lenticel and is at first dark brown in colour, later becoming black, the margin being definite or indefinite, and regular or irregular. Before it has reached any considerable size, however, perithecia develop as subemergent bodies, more or less globular with a prominent neck. No asci appear to be formed nor are conidia associated with the fungus while it attacks the fruit, though both develop freely in culture.

PLEOSPORA HERBARUM Pers.

This widely distributed fungus has been obtained only once, on the variety Bismarck. The rot was large, brown and shallow and developed from a lenticel.

Both perithecia and conidia (*Macrosporium commune* Rab.) appear in artificial culture. Neither stage has been hitherto recorded on the apple.

VALSACEAE.

DIAPORTHE PERNICIOSA É. and É. March.

This fungus is described by Él. and Ém. Marchal (24) who found it in Belgium attacking both the fruit and branches of the Pear, Apple, Plum and Peach. That it occurs also in this country and is a common cause of the well-known "Die-Back" of stone-fruit trees has been shown by Cayley (8). She finds that it occurs in both Cambridgeshire and Kent, from both of which counties the apples used in this investigation were obtained, so that although it is not recorded as infecting the apple trees themselves, there seems little doubt of the source of infection of the fruit.

When apples are stored for any considerable period the importance of this fungus is second only to that of *Penicillium expansum*, but being essentially a late storage rot, it is relatively unimportant during the short period apples are normally kept.

The rot is at first smooth, rather dark brown, often lighter at the margin. It spreads laterally and towards the centre of the apple in a uniform manner, unlike rots caused by *Polyopeus purpureus* var. *verus*, which spread more rapidly through the surface tissues than internally. When once the fungus has gained an entrance the rot progresses steadily until the apple has become brown throughout. At this stage the surface of the apple is still smooth and relatively firm to the touch with no external signs of mycelial growth or of fructifications. Very soon, however, small black bodies appear under the skin, often densely crowded together; these are masses of closely packed mycelium which ultimately emerge through the epidermis as

small, semi-globose, grey-black stromatic bodies, 200μ in diameter, which up to the present have remained sterile, so that it is impossible to state whether they are immature pycnidial or perithecial stages. The absence of necks does not negate the possibility of their being undeveloped perithecia, as, under cultural conditions, these are a late stromatic development.

The fungus grows well, though slowly, on most artificial media. On Crabill's synthetic agar, the manner of growth is very characteristic. The pycnidial stage forms a compact, robust white mycelium and darkens the middle region of the slant; the stromata, which are irregular in size and shape, appear after $1\frac{1}{2}$–3 months and are at first covered with brown mycelium, afterwards becoming smooth and black. Orange-pink masses or strings of spores exude later. The perithecial stage develops more slowly, showing scanty, white, fern-like, mycelial growth and no discoloration of the media; flattened brown-black stromata appear after three or four months, and the necks of the perithecia develop about a month later. These are brown-black when young, black usually with paler tips when mature, and straight or irregularly curved. The spores are exuded in buff-coloured masses.

Some inoculation experiments have been carried out at different times. Rots were readily formed when pycnospores were used and less readily from hyphae from perithecial cultures. Pycnidia developed and exuded spores on apple twigs and inoculations have been successful on the living tree but the experiments are not yet completed.

Diaporthe perniciosa is distinguished from *D. Mali* and *D. ambigua*, both of which occur on apple branches, by the very much longer necks and by the size of the spores. The spores of *D. Mali* are larger (18–25 × 4–6μ) and its necks are very short. The necks of *D. ambigua* are rarely elongate and the spores are slightly longer (15μ) and not constricted in the middle.

The identification of the pycnidial stage presents certain difficulties. Though the primary division of the stromatic section of the Sphaeropsidales is into those forms which have only one pycnidium embedded in the stroma (unilocular) and those having one to many (plurilocular), this distinction is of limited value, because of the variable character of the fungi in culture. The pycnidial stage of *D. perniciosa* shows all stages from a fairly regular single pycnidium embedded in a stroma to pycnidia with incomplete cross walls which in some sections would be thought to be plurilocular. To be definite on this point it is necessary to cut a complete series of sections of the stroma. Plate VII shows four sections of such a series. Él. and Ém. Marchal identified the pycnidial stage of *D. perniciosa* as

Fusicoccum Malorum Oud. and they figure stromata of the fungus with several pycnidia. We have, however, made sub-cultures from specimens kindly sent to us by Professor Marchal and by cutting microtome sections of stromata from these cultures, we have been able to trace the connection between all the irregular lobes of a pycnidial cavity, which in many sections appear to be separate pycnidia. The lobing is so complex that there is no plane in which all the connections between the lobes are visible.

The stroma must therefore be considered to be unilocular and the fungus cannot be placed in Fusicoccum or any other genus whose essential character is to possess two or more pycnidia in a stroma.

Cayley (8) placed the fungus in the genus Phomopsis. There are only two genera with unilocular pycnidia, Phomopsis and Dothiopsis, between which the only difference seems to be the frequent presence of filiform spores in the former. The two genera were founded at the same time (1884), Dothiopsis being split off from Dothiora and Dothiorella, and Phomopsis from Phoma. The genus Dothiopsis has received very little attention since; Diedicke (12) states that the structure of its stroma resembles that of Phomopsis and Plenodomus, but does not draw any conclusions as to its systematic relationships. Further investigation of the genus may lead to its fusion with Phomopsis.

The occasional presence of two types of spores, filiform, and hamate spores, 25–30 × 1–1·5 μ, in addition to the more normal ovate, elongate, spindle-shaped spores, 6–8 × 2–3 μ, cannot be regarded as a generic character since such occur in numerous species of most of the genera in the stromatic group (16).

In 1870 Nitschke (26) when establishing the genus Diaporthe called the former "stylospores" and stated that they frequently occurred in the pycnidia. Saccardo in his diagnosis of the genus Phomopsis also mentions the occasional presence of stylospores and Diedicke (11), who first showed that they were spores and not paraphyses, called the oval spores A-spores and the stylospores B-spores.

Several species of Fusicoccum possess both A- and B-spores, *e.g. F. viticolum* (34). They are not, however, specifically referred to in the original description of *Fusicoccum Malorum*. Unfortunately no drawings or cultures of the type are available, so it is impossible to be certain that they were not overlooked by Oudemans or regarded as conidiophores. An examination of sub-cultures from Marchal's pycnidial stage showed the presence of B-spores only in the young stroma, but A-spores developed later. In older cultures A-spores alone were found.

It is evident that the fungus is one of a group in which there

are no sharp lines of demarcation between the genera, and it is therefore essential when identifying a specimen to consult the descriptions of all known species in the group. We find that there are several species whose description would be appropriate for the pycnidial stage of *Diaporthe perniciosa*.

In the first place, *Fusicoccum Malorum* as described by Oudemans is identical with the present fungus, as we have shown that apparently separate pycnidia are really chambers of a single labyrinthiform pycnidium. It is, moreover, the only fungus of the group recorded on apple fruit in Saccardo's *Sylloge*.

The next species to consider, taking them in chronological order, is *Phomopsis Mali* Roberts (29, 30). This fungus causes a "rough bark" disease of apples and is capable of producing a rot on the fruit; it is very similar in its mode of attack to the "Die-Back" of stone-fruit trees in this country. As a result of an interchange of cultures, there is little doubt that *Phomopsis Mali* and the pycnidial stages of *D. perniciosa* obtained by Marchal, Cayley and ourselves are similar in general character of the stromata, size of spores and behaviour on Crabill's synthetic media.

This being so the name *Phomopsis perniciosa* f. *pruni* tentatively put forward by Cayley will have to give place to the earlier name *Phomopsis Mali*.

More recently, two American investigators, Chupp and Clapp (9), have described a fungus causing rotting of apples to which they have given the name *Fusicoccum Pyrorum*.

They state that the fungus closely resembles *Fusicoccum Malorum*, but having found it impossible to obtain specimens of the latter for comparison, they decided to create a new species.

They very kindly have allowed us to examine cultures of *F. Pyrorum*—and we believe it to be identical with *Phomopsis Mali*.

SPHAEROPSIDEAE.

PHOMA FULIGINEA sp. nov.

Pycnidiis atris, subglobosis, non ostiolatis, 250 μ diam., sporulis hyalinis, ellipsoideis, 5–7 × 2–3 μ, in cirros non exsilientibus; hyphis hyalinis; substrata artifacibus fuligineis.

This species has been isolated from Bramley's Seedling three times, from a small red sunken "spot" 2 mm. in diameter, from a small spot associated with an insect puncture and from a nondescript calyx rot.

PHOMA BISMARCKII sp. nov.

Pycnidiis brunneis, subglobosis, circa 300 μ diam., ostiolis multis, nigris, 30 μ diam., sporulis hyalinis, ellipsoideis, 5–8 × 2–3 μ, in cirros roseolos exsilientibus.

Isolated once from the variety Bismarck. The rot was dry, shallow and brown, arising at a lenticel.

POLYOPEUS PURPUREUS.

vars. VERUS, NIGRIROSTRATUS, LATIROSTRATUS and INCOLORATUS, Horne.

The genus Polyopeus, which was founded by Horne in 1920 (17), is distinguished from Phoma by the fact that under certain conditions the pycnidia develop tubular outgrowths or "necks." These necks vary in length from 48–240 μ and in number from one to several on a single pycnidium. They are well developed in culture, especially on Crabill's synthetic agar*, and generally on all media on which the fungus grows well. Distinct necks are also usually seen in cultures on sterilised apple twigs. But the development of protuberances must be regarded as essentially a cultural character, for on the apple the pycnidia are not distinguishable from those of Phoma and Horne diagnoses his species and varieties according to their behaviour on Crabill's synthetic agar.

Horne has regarded the fungi of this group as being associated only with the spotting of apples and does not include them among the common rot-producing fungi (43); but in our statistical survey of storage rots we have isolated from rots of considerable size fungi corresponding in cultural character to all four varieties of *Polyopeus purpureus*. In the earlier examinations they comprised the larger proportion of the fungi attacking the fruit. *Polyopeus purpureus* var. *verus* was the dominant variety, the others being comparatively infrequent. The rots caused by the different varieties are very similar in appearance. In some cases they are dry, brown, shallow, irregular in outline and progressing very slowly, but more commonly the diseased areas are smooth and circular with the edge sharply defined. In almost every case they arise at a lenticel. In colour they are bright brown often with a slight purplish tinge. Subepidermal pycnidia sometimes appear as brown, globose bodies but these, except in rare cases, remain sterile. Only *P. purpureus* var. *verus* has been observed to produce spores on the apple—by ourselves on Stirling Castle (see Plate VI) and by Horne on this variety and on Early River. On Stirling Castle the pycnidia developed and exuded spores freely when the rot was little more than two centimetres in diameter. The apples were not wrapped and the disease spread rapidly in the store. The rots are firm and rather dry, the apple ultimately becoming hard and mummified. Rots have been produced by artificial infection with all the varieties.

The fact that Polyopeus fructifies so rarely on the apple and

* Substituting wheat starch for maize starch.

is as yet known on no other host raises the question of the source of infection. It suggests the probability that it occurs in the orchard on the apple tree or on other hosts, perhaps there producing a different type of spore or even forming pycnidia indistinguishable from those of Phoma. Cultures on sterilised apple twigs spore freely. In some cases the pycnidia develop small necks but this character is not very pronounced.

Polyopeus Pomi Horne.

This species, which is characterised by the size and number of the beaks of the pycnidia, has only been found by us in mixed infections and then very rarely. No inoculations of apple with this species have yet been carried out.

Polyopeus recurvatus Horne.

Although frequently isolated from spots we have only twice isolated this fungus from an actual rot—in both cases these were small, dry, slowly developing rots. Its pathogenicity has not yet been established.

Cytosporella Mali Brun.

This species was described by Brunaud in France in 1893 (7) on apple branches. It has not before been recorded on the fruit. It has only been isolated once by us from a large brown rot covered with small black, sterile pycnidial bodies.

Cytospora personata Fr.

Fungi belonging to the genus Cytospora are a common cause of the "Die-Back" of fruit trees, including the apple, but in most cases the species has not been determined. *C. personata* has been recorded on the branches of *Pyrus Malus* (31) and by Él. and Ém. Marchal (24) on pear fruit.

We have obtained it once only, from an apple which was brown throughout with sterile stromata on the surface.

Sphaeropsis Malorum Peck.

This fungus is well known in the United States as a cause of fruit decay, of canker and of leaf-spot. It also causes a canker in Australia. In 1910 Salmon reported the first occurrence in England as a canker of the pear tree, and more recently the Ministry of Agriculture (45) stated that it is fairly widely distributed as a leaf-spot.

Horne records it as a common rot-producing fungus on apples, but in our experience it is met with only rarely in store, having been found once on Stirling Castle and once on Bramley's Seedling. Duggar (13), who gives a good photograph of the rot, states that, though often observed, it is not serious as a fruit rot in the United States.

CONIOTHYRIUM CYDONIAE Brun.

Horne (17) described a variety *Mali* of this species on the apple, the distinguishing character being the zoned manner of growth. Our cultures do not show zonation and the morphological characters of the fungus are identical with those of the species. The genus Coniothyrium has not been recorded on the apple except by Horne.

ASCOCHYTA PIRINA Pegl.

The variable character of the septa in the spores of Ascochyta and related genera is well known (5) and the cultures we have obtained (once from Bismarck and once from Bramley's Seedling) always show a considerable proportion of non-septate spores. The morphological characters are identical with *Ascochyta pirina*.

This species has hitherto only been recorded on the leaves and fruit of the pear in North Italy.

DIPLODIA MALORUM Fuck.

Four species of Diplodia have been recorded on the apple tree, viz. *D. Malorum* Fuck. on the fruit, and *D. pseudo-diplodia* Fuck., *D. maura* C. & Ell. and *D. piriformis* (Preuss) Sacc. on the branches. Of these the first three are very similar in character, so that it is difficult to be certain to which species our cultures belong. Provisionally they are assigned to *D. Malorum* Fuck. This species has been observed on decaying apples in Germany and Italy.

Only two isolations have been made in each case from dark brown rots at the stalk of the apple.

Artificial infections have not yet been carried out.

CYTOSPORINA LUDIBUNDA Sacc.

This fungus has been recorded in England on apples by Horne. It had been previously known on the branches of a number of trees though apparently not on Pyrus. The fungus does not grow well on synthetic media but spores readily on beer-wort agar. The rot is usually light brown with a definite margin; no fructification has been seen on the host. It arises at the stalk or at the calyx, rarely at a lenticel. The fungus was obtained twenty times during the season 1921–22.

MELANCONIEAE.

GLOEOSPORIUM ALBUM Osterw.

This has not been recorded before in England. It was first described in 1907 by Osterwalder (27) as attacking apples and pears in storage. Schneider-Orelli (33) described it as one of the most important rot-producing fungi and studied its growth under various

conditions of temperature. Él. and Ém. Marchal (24) described it as a common storage-rot fungus in Belgium. We have found it on both apples and pears, but it is one of the less frequent fungi. The rot produced is very characteristic. It is usually of lenticel origin, brown, with a definite, regular margin, the centre of the rot being sunken and paler than the rest, or the whole rot may have alternate light and dark brown zones. Acervuli develop later on which spores are ultimately produced. The fungus progresses relatively slowly both on the host and in culture.

G. FRUCTIGENUM Berk.

This fungus has only been isolated by us twice. The cause of a widespread disease in America and on the continent it is remarkable that it is not more prevalent in this country. It is generally supposed to cause damage in our stores. Schneider-Orelli (33) considered it of less importance in storage than *G. album*. Owing to the similarity of the descriptions of the rots it is probable that in this country rots caused by the latter fungus are often mistaken for Bitter Rot. Some of the Fusarium rots also are not unlike.

COLLETOTRICHUM GLOEOSPOROIDES Penz.

This fungus has only occurred once, but we have shown by inoculation experiments that it is capable of infecting the apple. *C. gloeosporoides* is a fungus very common on oranges. The form we isolated from apple agrees very closely with that we have isolated from oranges and it is interesting that Darnell-Smith (10) found that spores taken from Emperor mandarins could infect apples.

CORYNEUM MICROSTICTUM Berk. and Br. var. MALI, var. nov.

The fungus of the genus Coryneum isolated by us from rots of apples appears to agree closely with herbarium specimens of both *C. foliicolum* Fuck. and *C. microstictum* Berk. and Br. There would appear to be no well-marked differences between the two. Spore measurements are identical and diagnostic characters indicate that *C. foliicolum* usually possesses pointed olive-coloured spores, whereas in *C. microstictum* the spores are more usually rounded at the ends and honey-coloured. The spores of the fungus isolated by us have rounded ends and are distinctly olive.

C. microstictum is a widely distributed species. *C. foliicolum* is common in the orchards of America, occurring as a leaf-spot and also as a canker of apple trees. It has been shown by Lewis (23) to be capable of causing a rot of the fruit. *C. foliicolum* has been recorded in this country on apples, though only asso-

ciated with small spots and not active rots (18). The fungus isolated by us does not fructify on the apple and has been studied only in culture. In the absence of opportunity to make cultural studies of several species of Coryneum we have tentatively placed the species isolated by us as a variety of *C. microstictum* differing from the true form in the colour of the spores. We have shown by inoculation that it will cause a rot on the apple when penetration is brought about by injury of the surface cells.

Pestalozzia Hartigii Tub.

Three species of Pestalozzia are recorded in Saccardo on Pyrus, *P. rostrata* Zab. on apple bark, *P. breviseta* Sacc. and *P. concentrica* B. & Br. on leaves of the pear. A fourth, *P. funerea*, has been isolated from the apple by Brooks and Cooley (2). Our fungus, which was only obtained once, has 3-septate conidia measuring 16–18 × 6μ. It is therefore quite different from any of the above but closely resembles *P. Hartigii* previously only known on spruce in Central Europe.

Inoculations by the tube method failed, but on wounding, rots developed in each case which on isolation gave the original fungus.

HYPHOMYCETES.

Oospora Mali sp. nov.

Caespitulis rotundatis, albis; hyphis sterilibus repentibus; conidiophoris curtis, a mycelio haud distincta; catenulis conidiorum 50–150μ, conidiis hyalinis, ovoideis, 4–6 × 3μ.

A new name is given provisionally to this species owing to the difficulty of identifying the species of this and allied genera from verbal descriptions. It is a fungus very common in spots at the lenticels of both Bismarck and Bramley's Seedling (off Chalk) during the season 1922–23. It has only once been isolated from a rot but not yet re-inoculated on to the apple. No species of Oospora have hitherto been recorded as occurring on the apple.

Monilia fructigena Pers.

Although this is generally considered an important rot-producing fungus in the store (43, 45), it would seem from the results of a systematic investigation of such rots that this is not so. Among all the isolations of rots on Bramley's Seedling during 1921–23 only two were infected with this species, and in the three varieties studied in 1922–23 none at all. These apples were all "late keepers." In earlier varieties such as Stirling Castle infection was greater but even then it was only responsible for 5–10 per cent. of the total rots. It usually appears shortly after storing and if affected apples are thrown

out it will not reappear; if left in, a few of the neighbouring apples may become contaminated. Spinks (37) gives an account of the characteristics of this rot on a large number of varieties. As an orchard parasite it is well known.

CEPHALOSPORIUM MALORUM nov. sp.

Effusum, albidum, hyphis hyalinis, conidiis ovato-ellipticis, hyalinis, $4\mu \times 2\mu$, ad apices ramulorum in capitula irregularia congestis.

This species appears to be very similar to *C. robustum* Preuss which has been described on apple wood though not on the fruit. The description of this latter species is very inadequate and it is not possible to establish the identity of the two. *C. Malorum* up to the present has always been isolated associated with other fungi.

HYALOPUS PRUINOSUS É. and É. March.

This is one of the less frequent weak parasites of the apple. Although inoculations have shown it to be capable of direct infection it is generally associated with the attack of other fungi under natural conditions. When the apple is artificially infected with *H. pruinosus*, a small, shallow rot, either light or dark brown, is produced. The Marchals (24) described it as occurring only on the pear.

HYALOPUS ALBIDUS sp. nov.

Caespitulis effusis; tenuissimis, albis; hyphis filiformibus, gracilibus; capitulis conidiorum globosis 20–40, conidiis oblongo-cylindraceis, 12–15 $\times$ 3μ.

This species is readily distinguished from *H. pruinosus* in culture by its pure white growth. It resembles *Hyalopus Populi* Nijp. except that the latter has shorter spores (8–11 $\times$ 3μ). It has been isolated four times from lenticel spots and three times from small rots. Inoculation experiments have not yet been carried out.

PENICILLIUM EXPANSUM (Link) Thom.

This well-known species of Penicillium does extensive damage to apples in storage. It is one of the few fungi which spore on the apple, so that the chance of infection increases in the store in proportion to the increasing number of apples affected. Because of its wide distribution and because of the obvious loss that it causes this fungus has received considerable attention from investigators of apple rots but mainly in relation to its germination and growth at different temperatures, particularly low temperatures (2, 6, 43). It has often been regarded as entirely a wound parasite, but Zschokke (42) has shown that,

though it is incapable of penetrating the cuticle directly, it gains access to the flesh of the apple through wounds and also through the lenticel openings or gaps in the cuticle. Once it has penetrated the internal tissues it passes from cell to cell directly through the cell walls. In our own experience, an analysis of the mode of entry of the fungus in a large number of rots caused by *P. expansum* shows that in the greater number penetration has taken place through the calyx end, or by means of the broken-off stem, or by wounds such as insect punctures, and only rarely through a lenticel.

The rot is very characteristic. It is light brown with a watery appearance, circular, soft, smooth in the earlier stages, but often wrinkled concentrically near the margin. The internal tissue is watery, pale in colour, often with a distinct green tinge, the vascular tracts standing out as brown areas. Coremia may be formed early in the development of the rot and spores copiously produced.

* * * *

A number of other species of Penicillium have been isolated, and some of these have been identified for us by Dr Thom. They include *P. luteum* Zuk., *P. chrysogenum* Thom, *P. puberulum* Bainier, *P. rugulosum* Thom, and *P. stoloniferum* Thom. It is hoped, however, to give later a more comprehensive study of the Penicillia infecting apples in storage. Under some circumstances their attack assumes considerable importance.

Sporotrichum Malorum sp. nov.

Effusum, atro-griseum; hyphis intricato-ramosis, septatis, hyalinis, conidiis oblongis, hyalinis, 6–8 × 2–3μ.

The only other species of Sporotrichum recorded on apple fruit is *S. Thumenii* Sacc. (Pennsylvania); *S. Peckii* Sacc. occurs on apple wood. Both species, however, differ in the colour of the mycelium and in the size and shape of the spores.

The fungus has been isolated about thirty times. The rots are dark brown and rather dry and arise at a lenticel spot, insect wound, or at the calyx.

Cephalothecium roseum Corda.

This widely distributed fungus has generally been one of the fungi used when the temperature relations of apple rot fungi have been studied (2, 6, 33). Brooks, Cooley and Fisher consider it of little economic importance except in some areas where it may do great damage following scab. Horne states that it is a common rot-producer in cold storage in this country, but in our experience it is rare except under warm, moist conditions or on early, soft-skinned varieties. Inoculation experiments were carried out at

24° C., 15° C. and 8° C. At the highest temperature small rots were quickly formed, which on re-isolation gave *C. roseum*, but at 8° C. the fungus was unable to grow at all.

RAMULARIA MAGNUSIANA (Sacc.) Lind.

This fungus was formerly known as *Septocylindrium Magnusianum* Sacc. (25). The Marchals (24) found it on the pear, but it has not been found previously on the apple, its principal host being *Trientalis europaea*. The ascigerous stage was first found by Wollenweber on *Rubus fruticosus* and named *Neonectria Ramulariae*.

The conidia are cylindrical, obtuse, 1-septate (rarely continuous or 3-septate), 20–25 × 3·5–4·5μ. The red perithecia also develop in our cultures but, up to the present, have remained sterile.

The fungus has been obtained once only on the variety Allington Pippin. The rot was large, dark brown, soft and rather shallow, with a definite margin. Its parasitism has not been established.

ZYGODESMUS FUSCUS Corda.

This fungus has only been isolated once from a rot on an apple off Fen soil. Species of Zygodesmus are now usually placed in the genus Hypochnus. The absence of the characteristic basidia from our cultures, however, and the close agreement with the original figure and diagnosis appear to warrant the retention of Corda's name. The fungus has been recorded several times in this country on decaying wood.

CLADOSPORIUM HERBARUM Pers.

Although often associated with other fungi in rots, and more commonly following superficial scald, *Cladosporium herbarum* is capable of direct infection of the apple. This has been confirmed by artificial inoculations. The attack progresses very slowly, the rot is brown to black, dry and shallow. As an independent parasite it is not of much importance.

A. S. and E. V. Horne (18) isolated *C. epiphyllum* Mart. from apple spots, but Brooks and Hansford (4) consider that this species is indistinguishable from *C. herbarum*.

STEMPHYLIUM GRAMINIS (Corda) Bon.

Mycelium black, hyphae dark, transparent; conidia dark brown, slightly warty, 15–36 × 15–18μ, muriform with 1–3 transverse and one longitudinal septa.

The species closely resembles the description of *Soredospora graminis* Corda, with the exception of the "hyphis moniliformibus." The hyphae in our specimens are of the usual

Stemphylium type. Those drawn by Corda are quite anomalous for the genus and would appear to belong to some other species. Oudemans (28) considers that they are conidia of a species of Sporotrichum. This being so there would be little doubt that our species is *Stemphylium graminis*.

The fungus grows very well in artificial culture, having a characteristic black shiny appearance and producing abundant spores. It has only been isolated from lenticel spots but inoculation experiments have shown that it can be parasitic.

ALTERNARIA TENUIS Nees.

This is a common saprophyte and a weak parasite on many hosts. It has been shown by inoculation to be capable of infecting the apple through the lenticel but only if this has first been injured by ammonia vapour. The rot formed is smooth, dark brown with a definite but irregular margin.

Other species of Alternaria have been recorded on the apple fruit. A. S. and E. V. Horne (17, 18) record *A. Grossulariae* and *A. pomicola* Horne as occurring in spots. These differ from *A. tenuis* in size and shape of spores. Él. and Ém. Marchal (24) described the species they isolated from an apple rot as *A. tenuis* var. *Mali*, but as the fungus is so widely distributed and the differences are so slight it seems unnecessary to make this distinction. In America, Brooks, Cooley and Fisher (3) state that one or more species of Alternaria are commonly responsible for the rotting of apples but give no diagnostic characters of the species.

TILACHLIDIUM CINNABARINUM sp. nov.

Caespitulus cinnabarinus; stromatibus erectis, altitudine 5 mm. attingentibus, superne eleganter iterato ramosis, ramis extremis capitulum globosum, album, 20–40 μ diam. ferentibus; conidiis hyalinis, recte, cylindraceis, 5–8 × 2 μ.

Of the genus Tilachlidium only *T. Malorum* É. and É. March. has been found on the apple. It differs from this species in the orange colour of the synema, and the larger spores and capitula.

It is doubtful whether this fungus is capable of parasitising the apple directly—it has been obtained either from small spots at the lenticels or from rots having two or more fungi present. Artificial inoculations have not yet been carried out.

GRAPHIUM MALORUM nov. sp.

Stipitibus gregariis, teretibus, erectis, 5–10 mm., ex hyphis filiformibus, fuligineis constantibus, sursum non dilatatis; conidiophoris gracilibus, hyalinis; conidiis globosis, fuligineis, 3–4 μ diam.; capitula 10–20 μ diam.

This species has only been isolated once. It differs from *G. fructigenum* É. and É. March., the only species up to the present isolated from apples, in size and shape of spores. The latter are elliptical, 7–13 × 4μ.

TUBERCULARIA VULGARIS Tode.

The occurrence of this fungus is of special interest as its perithecial stage, *Nectria cinnabarina* Fr., is a common canker-producing fungus on apple trees. *Tubercularia vulgaris* has been recorded before on the fruit. It was obtained twice, forming a large pale brown rot with an indefinite margin.

Fusarium.

F. ARCUATUM Berk. and Curt.

This has not before been recorded on the fruit, but was first found on the bark of apple trees in North America. It is new to Great Britain.

In culture the conidia are copiously produced in effused cream or pale orange masses. They are 3–5-septate, 40–60 × 3–4μ in size. No blue sclerotia are formed.

The rot produced resembles that caused by *Fusarium fructigenum*, the apple ultimately becoming brown throughout; sometimes acervuli are formed.

Inoculation experiments have shown that it is capable of directly parasitising the apple.

F. ANTHOPHILUM (A. Braun) Wollenw.

This species is also new to Great Britain and has never previously been recorded on the apple. It occurs in Germany on the corolla of *Succisa pratensis*. We have met with it only once and have not yet proved that it is parasitic. It is nearly related to *F. avenaceum*, being distinguished by the pink colour of the plectenchymatous hyphae.

F. VITICOLA Thüm.

This species was discovered in 1878 on the vine (*Vitis vinifera*). It has been recorded on this host in England and on various other hosts in Europe but not hitherto on *Pyrus Malus*. It is a fairly common cause of rots in storage though much less important than *Fusarium fructigenum*.

The conidia are usually 3-septate, 36–40 × 3–4μ in orange masses. On Crabill's synthetic media copious mycelial growth and bright crimson coloration of the agar characterise the fungus. This crimson colour is soluble in alcohol and becomes greenish yellow with acid, violet with alkali. No sclerotia are ever formed.

The rot caused by *F. viticola* is similar to that due to *F. fructigenum*. The apple becomes brown throughout with tufts of white aerial hyphae on the surface. Inoculations of this fungus on the healthy apple have been successful in producing rots.

F. AVENACEUM (Fr.) Sacc.

Fusarium avenaceum has been recorded on various hosts but until Marchal recorded its occurrence on pear under the synonym *F. subulatum* App. & Wollenw. it was not known on any fruit. It is not of great importance in storage as we have met with it only twice. The long, slightly curved conidia measure 50–70 × 4μ and are 5–7-septate. On Crabill's medium the mycelium is floccose and a certain amount of crimson coloration is produced. Inoculations from single spore cultures have successfully produced rots.

F. FRUCTIGENUM Fr.

This is the most important species of the genus Fusarium occurring in apples in store.

The original description of *F. fructigenum* is incomplete, but in 1918 Wollenweber (40) emended the species and included in it both *F. Cydoniae* Allesch. and *F. Cydoniarum* Roum. He records its occurrence on a number of hosts in Europe and America but it has not before been identified in England.

The fungus grows readily on artificial media and forms blue-green sclerotia which are turned crimson with acid and blue or violet with alkali. Frequently also part of the agar is coloured green. The conidia are developed in bright orange masses; they are 3–7-, usually 5-septate, 30–45 × 3–4μ. Light has a pronounced effect on the growth. In many cases when the cultures are kept in the dark no spores are formed and no sclerotia, only the green colour in the agar appears; but if the culture is kept in the light the medium assumes a pink tint and spores are produced copiously. Even when a culture is able to produce spores in the dark, the spore masses are more copious and brighter in colour when formed in the light.

In an endeavour to trace the source of this infection we examined cultures from Bud-rot of apple blossom through the courtesy of Mr R. W. Marsh and found his culture identical with our species. "Bud-rot" appears to be a widely distributed disease and was first recorded in 1914 (44). Salmon and Wormald 1915 (32) described an unidentified species of Fusarium causing Eye-rot of the apple and their description also agrees closely with that of *Fusarium fructigenum*.

Although not always associated with the "eye" or calyx end of the apple this mode of entrance of the fungus is very characteristic in the store. The rot begins as a small brown circular area, the margin of which is definite and usually regular. After the whole of the apple has been permeated by the fungus white (sometimes yellowish) hyphae come to the surface through the lenticels, forming small tufts; later acervuli develop but these have not been seen to produce spores on the apple, although they do so on pears. The rot is firm in consistency and the diseased tissues are dry in texture.

Inoculation experiments have shown that *Fusarium fructigenum* is a vigorous parasite readily forming large rots at both 8° C. and 15° C.

F. CULMORUM (W. G. Sm.) Sacc.

This fungus was first described in this country in 1894 under the name of *Fusisporium culmorum* (36). It is more usually met with on cereals though it occurs on a variety of hosts. It was found by us causing a rot of an apple (Warner's King) while still on the tree. Inoculations from single spore culture on healthy apples have been successful.

F. MARTII App. and Wollenw.

Although isolated from apples only once it has been shown by inoculation to be capable of parasitising the fruit. Hitherto it has been recorded only on the potato and the leaves of *Pisum sativum*. Wollenweber includes *F. Coelogynes* P. Henn. in this species.

F. MARTII App. and Wollenw. var. VIRIDE Sherb.

This is distinguished in culture from the above by a characteristic green colour at the bottom of the slant in the case of Crabill's synthetic media. Artificial inoculations have shown the fungus to be parasitic on the apple.

CYLINDROCARPON MALI (Allesch.) Wollenw.

This fungus was formerly known as *Fusarium Mali* Allesch. but in 1913 it was placed by Wollenweber (40) in his new genus Cylindrocarpon. It is the conidial state of *Nectria galligena* Bres. and both stages have been found on branches of apple trees in Germany. The fungus has been isolated from apple rots in Belgium. The spores, which are formed in pale yellow masses, are 1–3-septate, obtuse, 20–45 × 3–4μ. It is rare on the apple, having been found by us only in a lenticel spot on Bismarck, and in a small brown rot on Bramley's Seedling. No inoculations to establish its parasitism have yet been made.

RAMULARIA HETERONEMA (Berk. and Br.) Wollenw.

Berkeley and Broome first described this fungus under the name of *Fusarium heteronema*. They obtained it from decaying pears, but it does not appear to have been found since in this country. It has been isolated by us from several varieties of apples on which it caused an ordinary brown rot, indistinguishable in any way. Inoculations have shown that it readily infects Bramley's Seedling.

On Crabill's synthetic media its appearance is very characteristic. The spores are developed on large sporodochia in sulphur yellow masses and the medium takes on a slight orange coloration. The spores are oblong, obtuse, slightly curved, 3–5-septate, 36–60 × 3–5 μ.

In conclusion we wish to record our indebtedness to Dr H. W. Wollenweber for the identification of the Fusaria and allied genera, and to take this opportunity of thanking him for his help with this difficult group. We have much pleasure also in thanking Dr C. Thom, for examining some of our Penicillia species; Professor Marchal, Professor Chupp, Dr J. W. Roberts and Miss Gilchrist for sending us cultures for purposes of comparison; Mr J. Ramsbottom for examining some of the cultures now described as new and finally Mr F. T. Brooks for criticism and advice.

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EXPLANATION OF PLATES VI AND VII.

Plate VI.

Fig. 1. *Polyopeus purpureus* v. *verus* on Stirling Castle.
Fig. 2. *Diaporthe perniciosa* on Bramley's Seedling.

Plate VII.

Figs. 1–5. A series of sections through a stroma of *Phomopsis Mali*, isolated from an apple and growing in culture. In 1 and 2 several cavities are visible in the stroma, but in other sections through the same stroma they can be traced to belong to one irregular cavity.

THE CAUSE OF CITRUS SCAB.

(With Text-fig.)

By E. M. Doidge, Assistant Chief, Division of Botany, Pretoria, and E. J. Butler, Director, Imperial Bureau of Mycology, Kew.

It is now well known that the disease called scab or verrucosis of the lemon is not caused by *Cladosporium Citri* Massee as originally believed, but by another fungus which has been described as the causal organism by Fawcett*, Winston†, and others, but not named as its mycological position was not determined.

Scab is a common disease in rough lemons in the more humid parts of South Africa and the organism which produces it has been isolated a number of times during the past three years. Inoculations with a pure culture of this organism have invariably produced typical scabs on young lemon shoots kept in a humid atmosphere. Its cultural characters agree with those so fully described by previous workers, especially Winston; and the formation of true conidia, enabling the systematic position of the organism to be determined, has now been obtained.

The hyphae are of two kinds: (1) immersed or stromatic, conspicuously septate, often toruloid, up to 3 or 4 μ in diameter; and (2) superficial, creeping, obscurely septate, 1·5 to 2 μ thick, and uniform. The true conidia have been found only on the latter, terminally or on short, lateral, usually unbranched hyphae (Fig. 1). They are formed terminally on the narrowed end of the hypha, but the latter continues growth by a very fine branch arising a short distance below the apex (Fig. 3), so that the terminal spore and its stalk are pushed over to a lateral position. By the rapid repetition of this process small, elongated "heads" (Figs. 2 and 3) of conidia are formed, one (the youngest) being always terminal, and the others attached to lateral stalks. The conidia (Fig. 4) are hyaline, unicellular, oval, sometimes slightly narrowed at the basal end, and measure 2–6·5 × 1·3–2 μ, mostly 3–4 × 1·5–2 μ.

On the immersed hyphae (Fig. 5) lateral, bud-like branches are often formed, which readily become detached and continue to grow by a process of very irregular budding, mixed with the development of short hyphae. These bodies, which have been

* Fawcett, H. S. Citrus Scab. Florida Agric. Exper. Stat. Bull. 109. 1912.
† Winston, J. R. Citrus Scab: its cause and control. U.S. Dept. of Agric. Bull. 1118. 1923.

described by previous observers, are probably of an oidial or chlamydospore nature and are not true conidia.

The fungus can be most satisfactorily placed in the form-genus *Sporotrichum*, amongst the heterogeneous elements of which it most closely resembles the animal pathogens. This resemblance is apparent not only in the spore characters but

Sporotrichum Citri n. sp. 1. A sporiferous hypha with early stages of fertile branches. 2. A hypha with well-developed conidial heads. 3. Stages in the formation of the conidial heads. The upper figure shows renewed growth taking place a little below the conidium. 4. Conidia. 5. Immersed hyphae with bud-like detachable segments, and some of the latter germinating. All ×900.

also in the peculiar growth in culture, especially the raised, convoluted colonies, sometimes with an outgrowth of spiny synnemata, and the marked colour changes on different media. The pleomorphism of the human pathogen *S. Schenckii* (*S.*

Beurmanni) is fully described by Davis*, and this paper, together with De Beurmann and Gougerot's monograph of the pathogenic species of the genus†, will serve to make the suggested relationship more clear. The specific name *Citri* is proposed (though the same or a closely allied species attacks the avocado pear), chiefly because the scab fungus has been so often referred to as *Cladosporium Citri* even after it was known that it was not a *Cladosporium* and was not the same as Massee's species. The following diagnosis has been drawn up from cultures.

Sporotrichum Citri Butl. n. sp. Mycelio superficiali ex hyphis repentibus, tenuibus, 1·5–2μ cr., obscure septatis, hyalinis, composito; conidiis parcis, initio acrogenis, solitariis, dein acropleurogenis, spiculas subcylindricas in ramis lateralibus mycelii formantibus, distincte pedicellatis, hyalinis, ovalibus, basi subattenuatis, 2–6·5 × 1·3–2μ (saepius 3–4 × 1·5–2μ); mycelio immerso ex hyphis copiose septatis, 3–4μ cr., irregulariter toruloso-ramosis, hinc inde ramulos ellipsoideos, facile desciduos ac conidia simulantes gerentibus (?chlamydosporos), composito.

In foliis, fructibus, ramulisque vivis Citri.

NOTE ON THE ASSOCIATION OF TILLETIA TRITICI WITH "EPILEPTIFORM CONVULSIONS" IN THE DOG.

By J. Russell Greig, M.R.C.V.S., Professor of Medicine, Royal (Dick) Veterinary College, Edinburgh.

Although convulsions of an epileptiform character are commonly met with in the dog, their association with spores of fungi has not, so far as I know, been recorded.

Recently three cases, showing epileptiform symptoms, which appeared to be associated with the spores of *Tilletia Tritici*, were admitted to the hospital of the Royal (Dick) Veterinary College. The symptoms were identical in each case. The animal was suddenly attacked by a series of convulsions, which continued for some hours, and terminated in coma; in two cases death resulted, but in the other case recovery took place, though the animal was subsequently destroyed. As a routine measure the faeces in such cases are examined for the presence of Ascarid eggs, and in case A, although no eggs of parasites were found, the faeces contained very large numbers of spores, which proved to be those of *Tilletia Tritici*. An examination of the abdominal organs was made *post mortem*, but no definite abnormality was

* Davis, D. J. The identity of American and French Sporotrichosis. Univ. of Wisconsin Studies in Science, II, pp. 104–130. 1921.

† Les Sporotrichoses. Paris, 1912.

found. In case B the faeces contained large numbers of the spores, which were found on *post mortem* to be present throughout the alimentary tract; they were also very numerous in the bile and urine, which in this case were examined microscopically. The brain unfortunately was not examined, and no definite macroscopic lesion was discovered in any other organ.

In case C, spores were present in large numbers in the intestine and urine. No definite lesion was remarked until the cranium was opened, when an acute cerebral meningitis was observed; smear preparations from the cerebral cortex again revealed the presence of the spores. In sections cut from brain, kidney, liver and spleen the blood vessels were seen to contain very large numbers of dark pigmented bodies; these showed much variation in size, ranging from mere particles of pigment to bodies 12μ in diameter; their nature is yet to be determined. Since the spores were so numerous in the urine it was expected that they might also be present in the blood stream. No spores have, however, been seen in sections of tissue containing blood vessels, and it is possible that these pigmented bodies may represent spores in a state of disintegration; on the other hand, they may be mere artefacts. Other workers have shown by feeding experiments that the spores of *Tilletia Tritici* are capable of being absorbed by the intestines and reaching such organs as kidney and liver; in one case the spores were found to have actually penetrated the placental membranes of a pregnant bitch. How an inert body, measuring about 18μ in diameter, is capable of such absorption and penetration presents an interesting problem.

Mr D. L. McWhirter, B.Sc., M.R.C.V.S., who has assisted me in the investigation, has examined the faeces of a number of healthy dogs and found that, although the spores of *Tilletia* are frequently present, they are by no means numerous. In many cases lengthy search was required before a single spore could be demonstrated, whereas in the faeces of affected cases commonly six and not infrequently twelve spores could be seen in a single field. *Tilletia Tritici* is a normal parasite of wheat, and since wheat straw is commonly used for bedding it is possible that this is the medium of infection.

Although our material is still insufficient to permit of our arriving at any definite conclusion, it appears probable that on occasion the spores of *Tilletia Tritici* may constitute a factor in the production of "epileptiform convulsions."

Further investigations are in progress, and it is hoped that a fuller report may be made later.

I have to thank Dr Malcolm Wilson, of Edinburgh University, who kindly identified the spores.

A NEW DISEASE OF THE GRAMINEAE: PLEOSPHAERIA SEMENIPERDA nov. sp.

(With Plates VIII and IX.)

By C. C. Brittlebank, Vegetable Pathologist, and D. B. Adam, Assistant, Department of Agriculture, Victoria.

Over a number of seasons "Take-all" is probably the most serious disease of wheat in Australia. It is difficult, however, to prove such a statement with figures as no survey or estimate of real accuracy has ever been made of the losses from the various cereal diseases in this country.

The name "Take-all" as applied to a specific disease, while undoubtedly strikingly apt, as such, necessarily covers a wide range of different plant conditions when used as a descriptive term for a disease. On this account, perhaps, it is not so fortunate, since, in fact, several fungi do produce the general symptoms of the true "Take-all" disease. The term, while it may not have led to a confusion of the various fungi concerned, certainly has led to an awkward vernacular nomenclature. Thus we find reference in the literature of this subject to the true "Take-all" disease and to the "so-called Take-all disease" of Illinois and Indiana—diseases which are now recognised as being caused by different organisms.

It is worthy of note that while *Ophiobolus cariceti* (Berk. and Br.) Sacc.(1) is the fungus most generally associated with the "Take-all" disease of wheat, records of its occurrence on oats are rare(2); particularly is this so in Australia.

In 1919, an outbreak described as "Take-all" disease was reported from Hopetoun, Victoria. Oats and wheat were both reported to be badly affected. Subsequent examination showed that it was not the true "Take-all" disease and that the same fungus was present in the diseased plants of both crops.

The plants were evidently affected while still young, many plants having died before they had tillered. The surviving wheat plants were stunted, the leaves were coloured yellow, turning brown towards the tips. The oat plants surviving were also stunted, the leaves were upright, narrow and either red or streaked with red.

The affected areas in both crops were roughly circular, from one foot to five yards in diameter. Affected plants are about one-third the height of normal plants. These diseased plants do not recover.

Affected plants were carefully removed and examination showed that the original seed had been destroyed by a fungus. Out of the diseased seeds, long, dark, parenchymatous synne-

mata protruded, from which arose numerous septate condiophores, bearing at their tips multiseptate conidia, either singly, or in a single whorl of from 3–7 spores (Fig. 1). A brown septate mycelium had also grown along the roots and about the base of the stem. Some of the hyphae bore conidia directly. The roots were injured about their bases.

A number of pure cultures of this fungus were obtained on a variety of culture media, including oat meal, wheat meal, starch, potato and nutrient agar. Each medium, with the exception of nutrient agar, gave similar growths, though of variable vigour. On nutrient agar the mycelium was at first hyaline but later turned a sooty brown. From the mature strands, septate conidiophores arose, the upper three cells of which were darker in colour than the rest. These conidiophores bore from 1–7 conidia (Fig. 3). Occasionally conidia were also borne directly on the mature mycelium.

The conidia were brown, slightly spindle-shaped, 3–10-septate, straight or very slightly curved, and rounded at the ends, the end cells being slightly lighter coloured than the rest, 75–110 × 12–18μ (Fig. 2). On oat and on wheat agar the mycelium was at first hyaline but subsequently became brown, and bore straight or slightly curved, 5–10-septate conidiophores, 220–350 × 7–9μ; the apical cells were dilute honey-brown to hyaline and bore typical conidia. From the centre of the cultures black to dark brown synnemata, varying in dimensions from 2–9 mm. × ·5 mm. arose, either single or branched, straight or curved, parenchymatous, cylindrical but tapering towards a lighter coloured apex. At first the synnemata were smooth but later were beset with conidiophores bearing typical conidia. At the base of the synnemata numerous pycnidia were formed which were solitary or gregarious, parenchymatous, greenish brown by transmitted light, 450–495μ in diameter, papillate, setulose, with simple setae which were straight or curved, continuous to 3-septate, tapering towards the apex, brown at the base, the colour diluting towards the tips, 150–170 × 5μ (Fig. 4).

The pycnospores were irregularly fusoid, continuous, hyaline or honey-brown in mass, 8–12 × 2μ. The pycnidial stage has never been encountered in natural infections, though it develops on inoculated wheat grains.

Perithecia also developed on these cultures and upon sterilised seeds of *Triticum sativum* Lam., *Avena fatua* L., and *Bromus sterilis*, L., all of which had been inoculated with conidia from a pure culture of the fungus. The perithecia were black, 650–680 × 250–500μ, with narrowed or shortly stalked base, densely hirsute, with bristles 350–380 × 10–12μ, straight or slightly curved, and tapering, 7–10-septate, some of the bristles functioning as conidiophores and bearing conidia at their

slightly swollen tips (Fig. 5). The asci were cylindrical, rounded at the apex, 450–580 × 30–35 μ, paraphysate, with filiform paraphyses, slightly longer than the asci. The asci were obliquely uniseriate, with muriform, yellowish brown, 7- rarely 8-septate ascopores, slightly constricted at all septa but most definitely at the medium septum (Fig. 6).

A large number of experiments were carried out to ascertain whether the fungus isolated on the culture media was responsible for the injury observed in oat and wheat plants at Hopetoun. Soil was sterilised by heating to 120° C. in an autoclave on three successive days. Wheat and oats "pickled" in 1 per cent. copper sulphate for three minutes, removed and washed three times with sterile water, were infected with conidia from a pure culture. Inoculation was effected by bringing the seed into contact with a spore cluster. The seeds were planted immediately in the sterilised soil and then covered with bell-jars. Check plants were grown under similar conditions except that the seeds were not infected with spores. Seedlings appeared from all seeds planted.

After twenty-nine days a marked difference in growth was noted between the inoculated plants and those in the check pots. The infected plants were stunted and weak, and similar in appearance to the original diseased plants. Close examination revealed typical mycelia, with synnemata bearing conidia, arising from the diseased grains. The bases of the roots were also injured. These experiments were repeated many times with similar results. Wheat seed was also successfully inoculated. Some grains were sterilised by being placed in 1–1000 mercuric chloride for ten minutes, washed three times in sterile water and infected with conidia by being placed in contact with a pure culture. The seeds were placed in a sterilised, plugged test-tube and removed to a cool place. Within ten days after inoculation dark pustules were noted beneath the pericarp. Five days later, the pericarp ruptured: after thirty days synnemata bearing conidia developed (Fig. 7): later still pycnidia and perithecia were produced. These were similar to those produced on the various culture media.

The suggestion that this fungus was the cause of the disease at Hopetoun was considered established.

This fungus, considering the Ascomycetous form, undoubtedly belongs to the genus *Pleosphaeria* Speg. (3).

The description of the conidial form agrees closely with *Podosporiella verticillata* described by P. J. O'Gara, with which we think the subject of the present study is identical. This fungus is represented as being the cause of a disease of germinating wheat in Salt Lake Valley, Utah, U.S.A. in the summer of 1915 (4).

The occurrence of conidia on conidiophores borne directly on the mycelium, and not only on synnemata, both in the natural infections and on the different culture media, however, was not recorded by O'Gara.

Again, while agreeing with him that the fungus is mainly harmful in that it destroys the endosperm, which should go to the nutrition of the embryo, we do not agree that it is entirely non-parasitic, in view of the observed injuries to the base of the roots and also to the fact that plants in more advanced stages, when they are independent of the original seed as a source of food supply, apparently succumb to the disease.

E. H. Smith (Berkeley, California, U.S.A.), in a communication, forwarded a sample of a sterile fungus isolated by him from Australian wheat. An examination revealed *Podosporiella*-like synnemata and conidiophores, but no conidia. The culture plate was thin, and we think had dried out before the fungus had produced conidia. O'Gara also noted this tendency to dry out as being a condition necessary to guard against, in order to get typical fructifications.

The perfect stage, *Pleosphaeria semeniperda*, was first observed as occurring on wild oats, *Avena fatua*, collected in 1898 by G. H. Robinson at Ardmona, Victoria. D. MacAlpine examined these specimens and assigned the name, *Pleosphaeria semeniperda*. However, such a species has neither been recorded, nor described anywhere to our knowledge: hence the present record and descriptions. The first specimen of the disease on wheat was obtained from a milling sample forwarded by Mr P. R. Scott (1913).

Further records of occurrences on different hosts are:

Bromus sterilis L. at Myrniong, Victoria, Coll. C. C. Brittlebank (1899).

Avena sativa L. at Hopetoun, Victoria, Coll. A. E. V. Richardson (1919).

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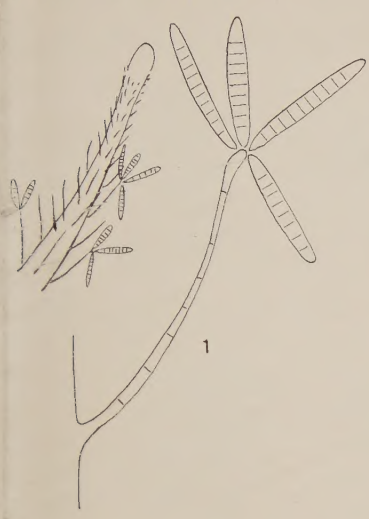
(2) Massee, G. "White-heads" or "Take-all" of Wheat and Oats. Bull. Misc. Inform. p. 435. Kew, 1912.
(3) Spegazzini, C. Fung. Argent. iv. Anal. Soc. Cient. Argentina, xii, p. 65. 1881.
(4) O'Gara, P. J. A *Podosporiella* disease of germinating wheat. Phytopath. v, p. 323. 1915.

EXPLANATION OF PLATES VIII AND IX.

Fig. 1. Synnemata, conidiophores and conidia of the *Podosporiella* stage of the fungus (enlarged).
Fig. 2. Conidia. × 1000.
Fig. 3. Types of conidia and conidiophores not borne on synnemata, found both in natural infections, and on culture media. × 500.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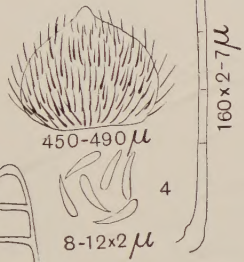
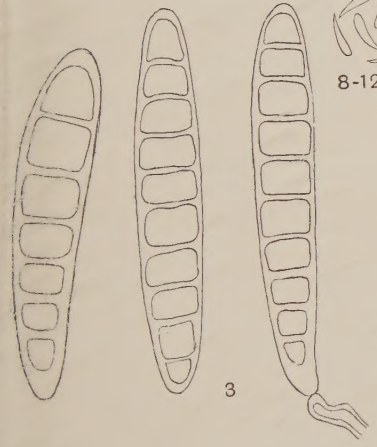

450-490 μ
160×2-7 μ
8-12×2 μ
4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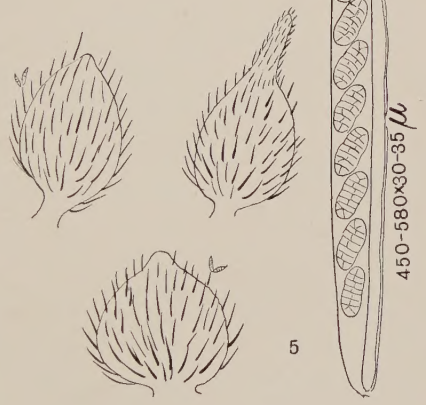
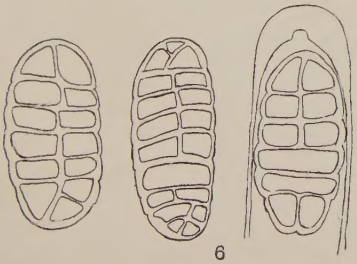

450-580×30-35 μ
5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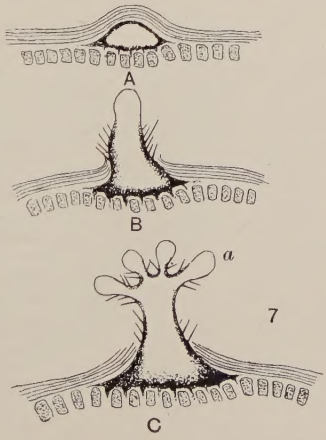
A
B
a
7
C

Fig. 4. Pycnidium with pycnospores and seta, from growth on artificial media, pycnidium × 75, seta × 500, spores × 1000.
Fig. 5. Perithecia, ascus and ascospores from growth on artificially infected wheat grain, perithecia × 75, ascus × 300.
Fig. 6. Head of ascus with ascospores. × 1000.
Fig. 7. Development of synnemata in an infected wheat grain, *B* a simple synnema, *C* a compound form, with young synnemata developing (*a*).
Fig. 8. Fertile synnemata produced on artificially infected grains.
Fig. 9. Development of fungus under epidermis.

NOTE.

A DISEASE OF NARCISSUS BULBS CAUSED BY A SCLEROTIUM-PRODUCING FUNGUS.

DURING the summer of 1922 Narcissus bulbs were sent to the Pathological Laboratory attacked by one or other of several troubles, the most frequent being the disease caused by eelworm. Amongst these bulbs, however, were some in which no eelworm could be found, but minute, black sclerotia were present, mainly in the outer, thin papery bulb scales, less abundantly in the next following thicker, fleshy scales, and in some cases they could be found in the innermost scales, *i.e.* in the foliage leaf bases. Rather noticeable white mycelium was also present on the fresh bulbs, especially between the scales, but this became less obvious as the bulbs dried off.

Cultures were made both from the mycelium and from the sclerotia in July, and in October (Scilly Isles) and December 1922 (Barr's bulbs) from the sclerotia alone. The fungus grew readily on both potato- and oat-agar and sclerotia were produced in great abundance in all the cultures irrespective of their source of origin. The cultures became quite black in appearance owing to the multitude of sclerotia produced throughout the media. These sclerotia are readily seen with a hand-lens. They vary considerably in size, but their diameter averages about 0·1 mm. Mycelium is not conspicuous in the cultures on the two media employed. No form of fructification appeared in any of the cultures, but micro-conidia occurred.

The fungus recalls in a general way that causing a disease of rice, *Sclerotium Oryzae* Catt. first described from Italy.

On January 15th, 1923, five healthy Narcissus bulbs were planted in pots of ordinary soil. These were inoculated by placing portions of an agar culture of the fungus on the unwounded apex of each bulb. The bulbs were afterwards covered with soil. A control uninoculated pot of Narcissus was grown beside them. The bulbs produced foliage in due course, that in the control pot being normal, healthy and superior to that in the other pot. On March 15th the two sets of Narcissus plants

were taken up and examined. Of the five inoculated bulbs, all had taken the infection and small sclerotia had already been produced in their scales. Four bulbs had not flowered, as the bud had died, and all were poor in growth; the fifth bulb produced one small flower. The fungus was isolated again from the bulbs and grew readily in culture.

In the control pot, all the bulbs were healthy, with no trace of sclerotia; the plants were well grown and had flowered.

This trial indicates that the fungus is a weak parasite.

During the spring and summer of 1923 Narcissi in various stages of growth with similar sclerotia on the bulbs were received on numerous occasions from the Scilly Isles (May to August), and the fungus was also found among Narcissus bulbs from various growers and salesmen received from other sources.

N. L. ALCOCK.

PROCEEDINGS, 1924.

MEETING. UNIVERSITY COLLEGE, LONDON. *19th January.*

Mr W. J. Dowson. *Sclerotinia sclerotiorum* affecting *Antirrhinum via* the stigma.
Major K. W. Braid. Some observations on "Stag-headed" oaks.
Miss G. Lister. A collection of Mycetozoa from Northern India.
Mr F. Howarth. Sexuality of *Ustilago.*
Mr T. A. Sprague. The principles of Nomenclature.

MEETING. UNIVERSITY COLLEGE, LONDON. *15th March.*

Miss E. J. Welsford. Diseases of Cloves in Zanzibar.
Miss M. Brett. Sclerotia formation in a species of *Sterigmatocystis.*
Dr J. Peklo. The work of Kruis and Šatava on the life-histories of yeasts.
Mr A. D. Cotton. Some notes on the Ministry of Agriculture's Plant-Disease Survey.
Mr E. Clement. A preliminary account of the germination of *Odontoglossum* and other orchid seed without fungal aid.

SPRING FORAY FOR LONDON STUDENTS. *3rd May.*

Visit to Byfleet.

SPRING FORAY, MATLOCK. *16th—20th May.*